DESIGN AND EVALUATION OF A HEALTH-FOCUSED PERSONAL INFORMATICS APPLICATION WITH SUPPORT FOR GENERALIZED GOAL MANAGEMENT

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DESIGN AND EVALUATION OF A HEALTH-FOCUSED PERSONAL INFORMATICS APPLICATION WITH SUPPORT FOR GENERALIZED GOAL MANAGEMENT

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For your health

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SUMMARY

The practice of health self-management offers behavioral and problem-solving strategies that can effectively promote responsibility for one's own wellbeing, improve one's health outcomes, and decrease the cost of health services. Personal informatics applications support health self-management by allowing their users to easily track personal health information, and to review the changes and patterns in this information. Over the course of the past several years, I have pursued a research agenda centered on understanding how personal health informatics applications can further support the strategies of health self-management—specifically those relating to goal-management and behavior change.

I began by developing a flexible personal informatics tool, called Salud!, that I could use to observe real-world goal management and behavior change strategies, as well as use to evaluate new interfaces designed to assist in goal management. Unlike existing personal informatics tools, Salud! allows users to self-define the information that they will track, which allows tracking of highly personal and meaningful data that may not be possible to track given other tools. It also enables users to share their account data with facilitators (e.g. fitness grainers, nutritionists, etc.) who can provide input and feedback. Salud! was built on top of an infrastructure consisting of a stack of modular services that make it easier for others to develop and/or evaluate a variety of personal informatics applications. Several research teams used this infrastructure to develop and deploy a variety of custom projects. Informal analysis of their efforts showed an unmet need for data storage and visualization services for home- and health-based sensor data.

In order to design a goal management support tool for Salud!, I first, I conducted a meta-analysis of relevant research literature to cull a set of proven goal management strategies. The key outcome of this work was an operationalization of Action Plans—goal management strategies that are effective at supporting behavior change. I then deployed Salud! in two fitness-related contexts to observe and understand the breadth of health-related behavior change and goal management practices. Findings from these deployments showed that personal informatics tools are most helpful to individuals who

are able to articulate short-term, actionable goals, and who are able to integrate self-tracking into their daily activities.

The literature meta-analysis and the two Salud! deployments provided formative requirements for a goal management interaction that would both incorporate effective goal management strategies and support the breadth of real-world goals. I developed a model of the goal management process as the framework for such an interaction. This model enables goals to be represented, evaluated, and visualized, based on a wide range of user objectives and data collection strategies. Using this model, I was able to develop a set of interactions that allow users of Salud! to manage their personal goals within the application.

The generalized goal management model shows the inherent difficulty in supporting open-ended, highly personalized goal management. To function generically, Salud! requires facilitator input to correctly process goals and meaningfully classify their attributes. However, for specific goals represented by specific data collection strategies, it is possible to fully- or semi-automate the goal management process. I ran a large-scale evaluation of Salud! with the goal management interaction to evaluate the effectiveness of a fully-automated goal management interaction. The evaluation consisted of a common health self-management intervention: a simple fitness program to increase participants' daily step count. The results of this evaluation suggest that the goal management interaction may improve the rate of goal realization among users who are initially less active and less confident in their ability to succeed. Additionally, this evaluation showed that, while it can significantly increase participants' step count, a fully automated fitness program is not as effective as traditional, instructor-led fitness programs. However, it is much easier to administer and much less resource intensive, showing that it can be utilized to rapidly evaluate concrete goal management strategies.

CHAPTER 1

INTRODUCTION

Two major factors that influence the health outcome and health service utilization (and associated financial costs) of an individual living with chronic illness are the type and quality of professional medical care that the individual receives, and the everyday decisions and actions of that individual which affect their condition. While many aspects of professional medical care may be outside of an individual's control, most individuals have a substantial amount of control over everyday actions and behaviors. In a traditional doctor-patient relationship, the doctor prescribes both the medical care and the behaviors to be undertaken by the patient to improve their health. However, as the patient goes through everyday life, there arise many opportunities to make trade-offs between actions that may improve health outcomes and actions that have other kinds of value (e.g. bring pleasure, or strengthen social relationships). The traditional patient-doctor relationship expects patients to follow doctor's orders at each such decision-point (e.g. "exercise more and consume less sodium") without much consideration for whether the patient will or can follow the instructions, or how specifically she is to do so. Patients are left to change their behavior in line with "doctor's orders" on own, but frequently lack the knowledge or skills to act appropriately on an ongoing basis.

Establishing the patient as a stakeholder in her or his healthcare is one method for dealing with this problem. As stakeholders together, the patient and her healthcare providers become partners and both take responsibility for the individual's wellbeing. Individuals and their physicians identify problems, hypothesize solutions, and share responsibility for outcomes. In an article in the Journal of the American Medical Association, Bodenheimer *et al.* describe two modes of this kind of partnership: collaborative care and health self-management education (HSM) [13]. Collaborative care is a stronger version of the partnership, in which a patient and her physician treat each other as experts: the physician in medicine, and the patient in knowledge of her own life. They then share responsibility for setting goals, deciding on strategy, and ultimately share responsibility for the patient's health outcome. Health self-management education does not shift the dynamics of the patient-doctor relationship as drastically, but still seeks to empower individuals to take responsibility for their health. Individuals living with chronic illness are taught problem-solving skills which, combined with the disease-specific information and technical skills taught in traditional patient education, enable patients to identify problems and take the actions necessary to overcome them. HSM education, when it works, provides the knowledge, skills, and self-confidence required to consistently behave in a healthier manner.

There is mixed support for the overall effectiveness of interventions involving health self-management education in improving health outcomes. In a literature survey, Bodenheimer et al. [13] found that eleven of twenty-three studies of asthma surveyed show improved outcomes for patients receiving additional self-management education, compared to a control group receiving only traditional education; for arthritis, twelve of eighteen studies surveyed showed improved outcomes for patients receiving self-management education, compared to a control group; the several studies of patients with diabetes surveyed also show some outcome improvement in patients receiving self-management education. A separate literature review by Gibson et al. concludes that "patients with asthma who are given self-care management education have a lower incidence of hospitalization, unscheduled physician visits, days off work, and nocturnal asthma" [38:266]. The same authors also conducted a review of information-only asthma education studies, and concluded that this type of educational curriculum has little or no effect on health outcomes of adults with asthma [39]. These meta-reviews studies suggest that HSM education can be a beneficial contributor to health outcomes, though it is not a silver bullet. In Chapter 2 of this dissertation, I will discuss the apparent differences between effective and ineffective interventions that include HSM education. For now, it suffices to say that some types of interventions that include HSM education are successful and that it is worthwhile to review this class of health programs in more detail. For ease of reference, I will refer to interventions that include HSM education simply as *HSM interventions*.

Theoretical and Practical Aspects of Health Self-Management Interventions

I will describe the Chronic Disease Self-Management Program (CDSMP) [57], which was developed and tested in a series of large-scale studies by Lorig et al. [59,60,61], as a cannonical example of effective HSM interventions. This example will highlight two theoretical underpinnings (the psychological constructs of self-efficacy and locus of control [LoC]) and two practical components (facilitators and goal-setting) of HSM interventions that enable them to support behavior change.

HSM Intervention Example: Chronic Disease Self-Management Program

The CDSMP is a community-based patient self-management education course that is taught to heterogeneous groups of chronically ill individuals, many with comorbid chronic conditions, over the course of several weeks. One of the underlying assumptions of the CDSMP is that “patients with different chronic diseases have similar self-management problems and disease-related tasks” [61:6], and therefore the program is designed to cover topics that apply to a wide range of chronic conditions: exercise, use of cognitive symptom management techniques, nutrition, use of medications, problem-solving, decision-making, etc. (see [60] for a complete list of CDSMP topics). To test the effectiveness of such a broadly encompassing educational program, the CDSMP was initially tested in a large-scale, controlled trial. Participants were individuals 40 years of age or older who had been diagnosed with a chronic lung disease, heart disease, stroke, and/or arthritis (the average participant had been diagnosed with 2.2 of these chronic conditions). The treatment group showed significant improvement on a range of measures of positive health behaviors (including exercise and cognitive symptom management), health status (including self-rated health, energy/fatigue and disability), and health services utilization (including fewer hospitalizations) [61]. Importantly, the authors found that the four disease categories showed no significant interactions for any of the outcome variables. The changes in outcome scores were similar in all four diagnostic groups—implying that the program was equally effective for participants regardless of their underlying condition.

Lorig et al. have further evaluated the Chronic Disease Self-Management Program in several contexts. The CDSMP was implemented in hospital settings, where it was offered as a treatment to chronically ill individuals [60]. This deployment represents a more “real-world” setting than the study described in [61] because participants were not recruited as “study participants” and the program was not taught in a controlled classroom setting. A comparison of participants’ health outcomes before the intervention and one year after the intervention showed improvements similar to those of the controlled study. Secondary analysis showed that the outcomes did not depend on whether group facilitators were health care professionals or lay individuals who only completed a twenty-hour training course [60]. To increase its potential reach, the CDSMP has been ported into an internet-based intervention in which participants interact with each other and with the group leaders via email and an online forum. Results of this evaluation show that the internet-based program has similar effects to the classroom-based program [59].

The Chronic Disease Self-Management Program is not without limitations. Participants must participate in a 7-week educational program, an investment of time and energy many chronically ill individuals may not be able or willing to make. Lorig et al. cite estimates that suggest only about 40-50% of eligible individuals would participate in such a program [60,61]. Those who chose to participate in the various CDSMP trials were more likely to be white and better educated than the average chronically ill individual. More problematically, there was a 20% dropout rate, and those who dropped out were more likely to be younger, nonwhite and unmarried [59,60].

The overall success of the Chronic Disease Self-Management Program regardless of chronic condition, medium of delivery (in-person or online), or group facilitator background (lay or professional) suggests that the structure and content of the curriculum is the key to its effectiveness.

Practical Aspects of HSM Interventions

Practically, HSM interventions, as exemplified by the CDSMP, support their participants' attempts at behavior change through two aspects: the availability of facilitators and by teaching goal management (as well as problem-solving).

By focusing on goal management, successful health self-management programs enable individuals living with chronic illness to identify and correct behaviors or habits that they judge to be inconsistent with their life and health ambitions. Through sound problem-solving, individuals can judge their condition and set personal goals that better balance their quality of life with their desired state of health. The goal-setting portion of the self-management curriculum then provides a guide for how goals can be met and revised, until desired outcomes are achieved. It is worthwhile to closely examine the psychological basis for this process of behavior change, as it forms a crucial step on the path to improved health outcomes. This process is important even for patients who prefer to have their healthcare providers set goals for them, as they must still change their behavior in accordance with the goals to reap any health benefits.

Group leaders (facilitators) also play a key practical role in HSM interventions. They assist participants in collecting, understanding, and acting on personal health information that may otherwise be overwhelming or murky. It is interesting to note that during evaluations of the CDSMP, professional and lay facilitators (who had only twenty hours of training) were equally effective at assisting participants through the intervention [60]. The lay facilitators were themselves individuals living with chronic illness, who had previously gone through the program. These facilitators served as models for the new participants—individuals similar to themselves who had gone through the program and were now successfully managing their chronic illness. This process of modeling has the additional benefit of increasing participants' self-confidence, as will be discussed later in this section.

Theoretical Aspects of HSM Interventions

The CDSMP curriculum is based on strategies for enhancing *self-efficacy*—a psychological construct reflecting an individual's expectation of her ability to produce a desired result [4]. Lorig et al. cite weekly action planning, behavior modeling, problem-solving, reinterpretation of symptoms and brainstorming of different management techniques—all both individually and with the group—as activities undertaken by program participants and facilitated by group leaders in order to enhance participants' self-efficacy [61].

Along with self-efficacy, a second psychological construct important in CDSMP and other HSM interventions is *locus of control* (LoC), which operationalizes an individual's beliefs about the factors that affect her health. Both of these are presented in detail below, as they form the theoretical foundation for the transfer of HSM strategies into personal informatics applications [52,54], which will be presented in subsequent chapters.

Self-Efficacy

The theory of behavior change adopted by Lorig et al. in the development of the Chronic Disease Self-Management Program is based on Bandura's theory of self-efficacy [4]. This psychological variable is a measurement of an individual's efficacy expectations in undertaking a behavior for a given outcome (see Figure 1.1). An individual's expectations of efficacy mediate the initiation of coping behaviors, as well as persistence in the face of failure. In other words, an individual with high self-efficacy toward a particular behavior is more likely to try to cope with situations that call for the behavior. She is also expected to try harder and persist longer at the behavior when faced with failure. Conversely, an individual with low self-efficacy expectations is less likely to initiate the coping behavior—even if she believes that successful performance of the behavior would produce desirable outcomes. This individual is also less likely to persist if initial attempts fail. According to Bandura, efficacy expectations are a better predictor of future performance than either past performance or outcome expectations [4].

Bandura describes three dimensions of efficacy expectations: magnitude, generality and strength [4]. Variations in magnitude refer to the difficulty of tasks from a set of related tasks that an individual expects to accomplish (e.g. running one mile vs. running two miles vs. running a marathon). Variations in the strength of efficacy expectations describe their susceptibility to be extinguished by disconfirming experiences; weak expectations are easily extinguished, while strong expectations can withstand multiple strong disconfirming experiences. Finally, generality refers to how broadly the sense of efficacy extends beyond a specific situation. The development of strong, general efficacy expectations of an appropriate magnitude about health behaviors is therefore an excellent outcome for a health self-management intervention.

Bandura goes on to describe four methods by which increased self-efficacy expectations may be induced. The most influential is performance accomplishments based on personal mastery [4]. In this scenario, the individual performs the same behaviors for which stronger self-efficacy is desired. Repeated successes raise mastery expectations, while repeated failures lower them. The timing and total pattern of experiences is important, as early failures can strongly demoralize an individual, while efficacy expectations strengthened by repeated successes are more likely to withstand setbacks encountered later. Lasting, generalized changes in self-efficacy are “best achieved by participant methods using powerful induction procedures initially to develop capabilities, then removing external aids to verify personal efficacy, then finally using self-directed mastery to strengthen and generalize expectations of personal efficacy” [4:202]. Vicarious experience—watching a therapist or model successfully accomplish a behavior—can also induce increased self-efficacy. However, this effect is not as strong as personal performance because the vicarious experience provides less information about one’s own capabilities. Finally, verbal persuasion and emotional arousal can help induce expectations of efficacy, however these tend to be small and short-lived compared to the other methods.

<u>Locus of Control</u>

The second mediating variable for behavior change shown in Figure 1.1 is *outcome expectations*. In health self-management, outcome expectations refer to an individual’s assessment of the benefit of successful behavior change. This assessment is captured in the Multiple Health Locus of Control (MHLC) metric developed by Wallston and Wallston [89]. The MHLC operationalizes an individual’s beliefs about the factors that affect their health along three dimensions: internal (IHLC), powerful others (PHLC) and chance (CHLC). These three dimensions are independent, and vary according to how much an individual believes their health is affected by their own actions, the actions of powerful other people (nurses, doctors, etc.) and by luck or fate, respectively. Compared to other comparable measures of health locus of control, the MHLC has been found to be more internally consistent and reliable [89].

Wallston and Wallston [89] report that studies provide mixed results with regard to whether individuals who have high internal locus of control engage in more preventative health behaviors or adhere more closely to medical regiments. However, Smith and Wallston [83] suggest that this outcome is to be expected, and caution against using locus of control as a sole predictor of health behaviors and outcomes. They go on to suggest that the value of health to an individual, a metric that differs significantly from person to person, together with locus of control is a better predictor. Because of the difficulty in measuring the value of health, Wallston and colleagues have adopted a modified version of the Rokeach Value Survey [77] as a proxy for this measure. The modified instrument consists of ten values, including health. Participants rank the values in order of desirability, from the highest to the lowest. The Relative Health Value (RHV) is then found as the distance between the rankings of “health” and “an exciting life” [90].

A high internal locus of control, together with a high Relative Health Value, would appear to be beneficial to an individual with a chronic condition, as she or he would (correctly) believe that her actions can have an impact on her health. Thus, increasing IHLC would appear to be a positive outcome of an HSM intervention, assuming that participants already value their health (whether or how health value can be influenced is outside the scope of this work). It is also important to note that Wallston and Wallston postulate that individuals who score highly on the PHLC and CHLC dimensions may be in a better position than those who don’t to both accept the advice of medical professionals and avoid blaming themselves or their caretakers if well-intentioned actions do not lead to improved outcomes [89]. Therefore, an individual who scores highly on all dimensions of the MHLC may be in the best position to deal positively and constructively with a chronic condition.

The four aspects of HSM interventions, building self-efficacy, internalizing locus of control, providing a facilitator, and effective goal-setting, will be explored in much more detail further in this dissertation. The ultimate objective of the research presented in this dissertation is to understand how HSM strategies related to these aspects can be effectively integrated into personal health informatics applications, and whether doing so better supports their users in changing health-related behaviors.

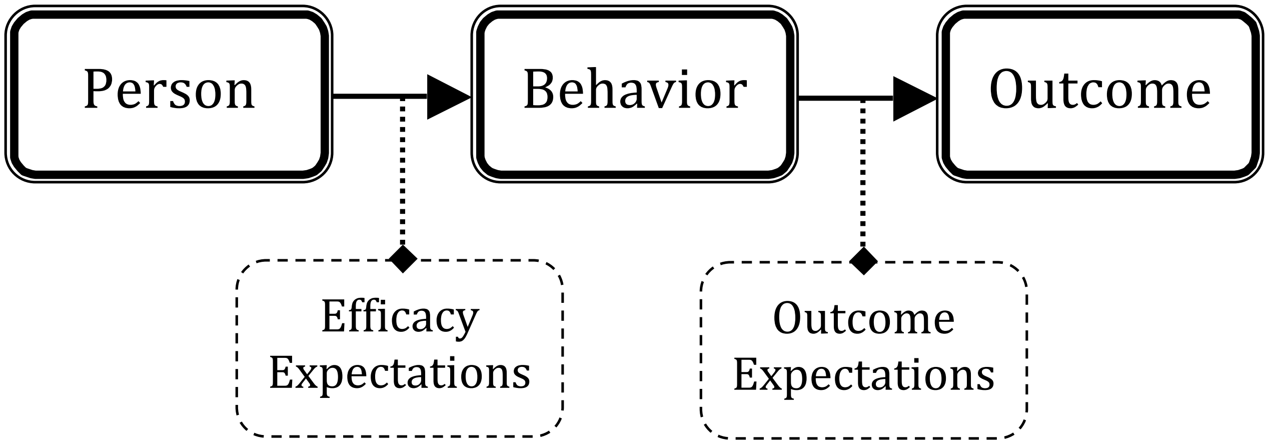

Figure 1.1 A model of behavior change, showing two key mediating variables. Adapted from [1].

Existing Research on Technology for Personal Health

There are a number of threads of previous research into improving health outcomes or supporting health self-management through interactive systems. The approach most relevant to the work presented in this dissertation involve applications that share some of the properties of personal informatics applications—systems that allow their users to track and review personal health information such as diet or exercise. Health self-management programs usually ask participants to keep records of their activities, physiological variables and other health-related data, and personal informatics applications can make this process simpler and easier.

Mamykina *et al.* have shown that collecting records of diet, exercise, and blood glucose readings, and sharing these with a diabetes educator results in improved health outcomes and a move toward internal locus of control among individuals newly-diagnosed with diabetes [62]. Diabetics who used Mamykina's systems where more reflective about their condition, which led to improved self-understanding and a greater sense of personal control over health outcomes [62,63,64]. This work supports the claim that an available history of one's own physiological data can support health self-management. However, Mamykina's systems did not have specialized interfaces to support self-management—such functionality either did not exist [63] or was provided directly by a professional educator [62].

Frost, Smith, *et al.* have also developed applications to help individuals living with diabetes to capture records of health-related activities [34,82]. These systems are designed to help individuals reflect on their actions and experience, and are effective at generating reflection and discussion in communal settings (e.g. wellness classes or support groups). However, the focus of this work is to develop better visualization interfaces for the review of records [34,82]. The applications do not directly address strategies for improving health outcomes based on individuals' reflections. Frost's recent work with PatientsLikeMe has shifted to providing tools for individuals to share experiences, strategies and support with respect to a common illness [35].

A great deal of recent work describes personal informatics applications that use elements of social competition and/or persuasive technology [30] to improve health or encourage healthy activities. These systems usually automatically (or semi-automatically) record a fixed number of health-related metrics and display this record back to users through an interface that encourages competition (e.g. [55,86]) and/or provides personal incentives to improve (e.g. [22,55]). These systems have shown success in improving attitudes towards fitness and increasing physical activity. However, they generally focus on a few hard-coded health/wellness metrics and rely on modeling, persuasion or emotional arousal to encourage desired behaviors. As a general rule, these systems do not primarily seek to increase self-efficacy through experiences of personal mastery, and do not provide the means for users to set self-selected goals.

There is a great deal of commercial interest in personal informatics applications for health. Several companies offer physical devices that allow individuals to track physiological data, which is then made available for review online. The most common type of device is a pedometer, which may be stand-alone (e.g. Fitbit) or integrated into a multi-purpose device like the iPhone (e.g. iTreadmill), though devices to track a variety of other physiological variables are available as well (e.g. bodybugg). Other companies provide desktop and/or web-based interfaces to track health-related activities and metrics. The majority of these tend to focus on a particular health or wellness issue such as diet or exercise (e.g. Weight Watchers Online), though several open-ended applications that can be used to track a variety of variables do exist (e.g. TheCarrot.com, Grafitter). While these applications promote their value for increasing motivation and helping users make sense of complicated health/wellness conditions, at this time only anecdotal evidence for these claims is available.

Because of this dissertation's inclusion of facilitators as key potential contributors to healthy behavior change, a final emerging thread of research that can be considered is work with virtual trainers, such as [16]. They key difference between such applications and the research I am proposing is that the virtual trainers, as of yet, only serve to guide or model specific actions for users. This is the same of virtual fitness coaches present in modern video games such as those for the Wii or Xbox Kinect. Such virtual agents can only model specific behaviors (e.g. squats or lunges); they do not yet model patterns of behavior (like the minimally trained facilitators of CDSMP), nor can they provide personalized guidance (like human personal trainers or nutritionists).

Research Contributions and Dissertation Overview

This dissertation centers on several research contributions regarding the extension of a personal informatics application to incorporate effective goal management strategies. In the first several chapters, I present formative work, including the uncovering of said strategies from related literature and the development of personal informatics software that is later retooled for goal management. In the following chapter, I present a meta-analysis of relevant research literature to cull a set of proven goal management strategies that could be implemented in software. Then, I describe the development of a flexible personal informatics tool, called Salud!, that I use to observe real-world goal management and behavior change strategies, as well as use to evaluate new interfaces designed to assist in goal management. This tool was built on top of an infrastructure consisting of a stack of modular services that make it easier for others to develop and/or evaluate a variety of personal informatics applications. I deployed Salud! in two fitness-related contexts, both involving facilitators (personal trainers) and clients, to observe and understand the breadth of health-related goals individuals work towards in everyday life. This portion of the dissertation includes four research contributions:

1. A design overview of Salud!, a personal informatics application that allows users to track a wide variety of personally-relevant data, in a way that's most meaningful to the individual user. Salud! also allows a user to share her account with a facilitator who can assist with account setup, input data, and provide expert feedback.
2. An analysis of the utilization of the Salud! open service stack, which was used by other researchers to create personal informatics tools and conduct external personal health informatics research.
3. The identification of a set of proven behavior change strategies, culled from research literature, which enable effective goal management and can be implemented in computational systems.
4. An analysis of how goal management is practiced in diverse, real-world fitness settings. This analysis is based on qualitative, longitudinal studies of how personal trainers and their clients used the Salud! application in two different contexts.

The focus of the dissertation then shifts to how goal management interactions can be designed into personal informatics applications, and the evaluation of such a system. The literature meta-analysis and the two Salud! deployments provided formative requirements for a goal management interaction that would both incorporate effective goal management strategies and support the breadth of real-world goals. I developed a model of the goal management process as the framework for such an interaction. This model enables a software system to fully represent, evaluate, and visualize a goal based on a wide range of user objectives and data structuring strategies. Using this model, I was able to develop a set of interactions that allow users of Salud! to manage goals within the application. In this way, I integrated support for goal management into a flexible personal informatics application, potentially making it a more effective tool for realizing behavior change.

The generalized goal management interaction requires expert input to correctly process, structure, and display goals based on their underlying data and user objectives. However, for specific goals with known data representations, it is possible to fully- or semi-automate the goal management process. I ran a large-scale evaluation of Salud! with the goal management interaction to evaluate the effectiveness of a fully-automated goal management interaction. The evaluation consisted of a common health self-management intervention: a simple fitness program to increase participants' daily step count. The results of this evaluation suggest that the goal management interaction may improve the rate of goal realization among users who are initially less active and less confident in their ability to succeed. Additionally, this evaluation allowed me to compare the effectiveness of a fitness program where the interaction is fully automated to traditional, instructor-led fitness programs. This second section of the dissertation includes two research contributions:

5. A generalized model of the goal management process. This model is consistent with effective goal management strategies present in theory, as well as real-world practices of goal setting. The model is articulated in sufficient detail to be implemented in software.
6. An evaluation of a fully automated goal management interaction based on this model. The effectiveness of the novel goal management interaction is compared to that of a naïve goal management interaction.

CHAPTER 2

EFFECTIVE GOAL MANAGEMENT STRATEGIES FOR HEALTH AND WELLNESS

This dissertation focuses on developing an application (Salud!) that supports individuals in improving their health and wellness through *healthy behavior change*—improved diet, increased exercise, and/or other positive changes in lifestyle and everyday behaviors. As noted in Chapter 1, other researchers have designed and evaluated many computational systems that attempt to accomplish this goal (e.g. [22,34,35,55,62,82,86]). One way to develop systems that bring effective behavior change to individuals without the use of facilitators is to create effective behavior change interfaces/interactions. Indeed, there is an ongoing search in the HCI community for theoretical foundations and effective design principles for computational systems that support healthy behavior change. This chapter begins by briefly outlining the related HCI work in this area.

The focus of the chapter, however, is a survey of effective behavior change strategies culled from health-self management (HSM) literature. As noted in Chapter 1, HSM interventions have been shown to be effective at improving participants' health outcomes. If effective behavior change strategies can be distilled from HSM interventions, they can be operationalized into interactive applications. Upcoming chapters describe how several of the strategies outlined in this chapter were integrated into features of Salud!, and the evaluation of those features.

Related Work

Several researchers have proposed design guidelines and theoretical frameworks for developing interactive applications that support individuals in attaining changes in behavior related to personal health. Consolvo and colleagues have proposed design guidelines for goal-oriented, persuasive systems that encourage physical activity [20,21]. Campbell, Ngo and Fogarty have suggested a set of design principles for everyday fitness games [17]. Mamykina *et al.* presented design implications for supporting individuals living with chronic illness in engaging in sensemaking and reflective practice [62]. Effectively engaging in sensemaking and reflective practice can increase internal locus of control and assist in behavior change with regard to diet, exercise and other wellness activities. Li presented a stage-based model of personal informatics that describes the design of self-monitoring systems and their use [52].

The work presented in this chapter differs from these previous approaches by specifically examining literature outside of the HCI domain. The strategies I present are distilled from work in HSM and psychology—fields where there is substantial collected evidence on the effectiveness of different approaches to health-related goal management.

Health Self-management Programs

Designers of health and wellness applications are constantly looking for effective theoretical and practical guidelines to assist with the development of applications that support healthy behavior change. Here, I present a set of design principles distilled from the research literature on health-based educational programs for individuals living with chronic illness (health self-management interventions) [13,58]. Some of these interventions have been shown to help participants realize improved health outcomes and an increased quality of life through behavior change around nutrition, exercise, medication management and other factors (e.g. [13,23,38,60,61]). My objective in undertaking this portion of my research was to identify the effective behavior change strategies used in the successful interventions, so that they may be leveraged in computational systems.

So far, computer applications have not been utilized heavily to support health self-management (HSM) interventions. The intervention programs are traditionally led by an instructor or facilitator, and computing technology is used for the purpose of distributing educational materials, not as a means of supporting behavior change (e.g. [59]). It thus remains to be seen whether computational technology could be used to support existing HSM programs, as well as to make some of the benefits of these interventions available to a broader population of users. To establish the foundation for this inquiry, in this chapter I will:

1. Highlight effective strategies for encouraging healthy behavior change that are used in health self-management programs.
2. Discuss about how these strategies may be effectively incorporated into computing applications that support behavior change.

Strategy Selection Procedure

To identify the set of strategies presented in this chapter, I reviewed published evaluations of health self-management programs. I reviewed a total of seven meta-analyses evaluating the effectiveness of various HSM interventions and goal management strategies [13,15,18,56,71,76,87], three books targeted at health professionals involved with HSM programs [5,57,58], and twelve additional research papers describing individual clinical studies of HSM programs [3,6,12,23,24,38,39,40,59,60,61,65]. From this literature set, I focused on the HSM interventions that were shown to have a significant effect on the behavior and/or health outcomes of their participants. Within the descriptions of those programs, I tried to identify the specific healthy behavior change strategies utilized. In identifying such strategies, I focused on those that met the following requirements:

- Apparent relationship between the strategy and the success of the health self-management intervention.
- Potential for the strategy to be applied broadly across the health and wellness domain.
- Potential to leverage the strategy in interactive applications.

Published evaluations of HSM interventions usually evaluate the program as a whole. As such, I frequently looked to the discussion and recommendations provided by the studies' authors to help understand whether and how a utilized strategy impacted the success of the intervention. I judged a strategy's generality based on the variety of health conditions to which the interventions that incorporate the strategy have been applied, and based on the generality of the strategy's psychological foundation (if discussed). Finally, I evaluated a strategy's potential for use in interactive applications by looking to existing work in the field and based on my own experience as a system developer and interaction designer. Notably, none of the strategies that I culled from the literature set require specialized training, the existence of a social cohort, or a trained facilitator. These are broad strategies, which can be used by a single individual and integrated into even relatively simple applications.

Five Strategies for Positive Behavior Change

In this section, I describe the five strategies that emerged from the selection process described above. For each strategy, I present the evidence for its inclusion, describe how it is integrated into existing HSM programs, and discuss how it may be leveraged in interactive systems that support behavior change.

Strategies Based on Action Plans

Three strategies in this list are related to "action plans," a practical element of health self-management interventions the presence of which has been shown to be a shared factor among a majority of successful programs [13,38]. An *action plan* is a short-term goal agreed upon by an individual and her healthcare provider, and which the individual feels confident she can achieve [13,58].

Strategy 1: Set Specific, Short-term Goals

The first component of an action plan is a specific, short-term goal. The goal should be quantifiable, as opposed to a "do your best" goal. The recommended timeframe for realizing it is between one and two weeks [13,58]. Specific, short-term goals help individuals build self-confidence about their ability to execute a new behavior (such as exercising or eating differently). These kinds of goals embody a clear distinction between success and failure, in contrast to non-specific, "do your best" goals, which rely on the individual to judge whether she performed adequately. Realizing a specific goal, even if it is not very challenging, builds self-confidence and encourages continued effort to realize more challenging goals [4].

Interactive applications that make use of goals to facilitate healthy behavior change should encourage users to set short-term goals—one or two weeks into the future. The goals should be specific, such as a concrete number of steps to walk, a specific reduction in the amount of calories consumed daily, etc. Applications that allow the user to set qualitative or abstract goals should encourage and support the user in splitting such goals into specific, short-term components.

Strategy 2: Set Actionable Goals

The second component of an effective action plan in health self-management programs is an emphasis on actionable goals. An *actionable goal* is one tied to a behavior over which the individual has direct control [13,58]. Examples of actionable goals include reducing the amount of sodium in one's diet, or walking a certain distance. In contrast, goals that are *non-actionable* include those related to body weight, blood pressure or other physiological measures. While managing these non-actionable factors is frequently the ultimate objective of healthy behavior change, this outcome is best viewed as the result of specific, direct actions [58].

Setting a specific, but non-actionable, goal creates an opening for failure and loss of self-confidence. Failing to achieve such a goal does not provide an individual with feedback as to what went wrong. Thus, interactive applications that support healthy behavior change should promote actionable goals. If a user is allowed to set a non-actionable goal, such as a body weight target, it should be paired with related, actionable goals such as minutes of exercise or daily calorie intake. The metric underlying the non-actionable goal can then be used as a reference for whether achieving the actionable goals is having the intended effect.

Strategy 3: Set Goals the User is Confident She Can Attain

The third behavior change strategy present in interventions that make use of action plans is the stipulation that a participant should only set goals that she is confident she can realize. Realizing a goal raises the participant's self-confidence about her ability to successfully perform the behaviors needed for this goal (or even a more challenging one) in the future; failing to realize a goal may low the participant's self-confidence regarding future performance [4]. Thus, participants in successful HSM programs are In some health self-management interventions, this requirement is operationalized by asking participants to rate their confidence of realizing a goal on a scale of 0 to 10 [13]. If a participant rates her confidence below 7, the goal is revised in a way that makes the individual more confident in a successful performance (usually by making the goal's target easier or simpler).

To leverage this strategy, interactive applications should gauge the user's expectations of success before allowing her to finalize a goal. This can be done via a simple interface that asks the user to rate her perceived likelihood of success, as described above. Additionally, an application can utilize this strategy to encourage the user to challenge herself by progressively adjusting the goal's target. By allowing the user to rate her likelihood of success at each increment, it is possible to ensure that the goal is adjusted at a reasonable pace. This can allow designers to create applications that challenge users, but also mitigate the chance that excessively difficult goals will lead to failure, and thus potentially decrease the user's self-confidence or engagement with the system.

Other Strategies

Strategy 4: Use Cues-to-Action to Trigger Behaviors

The basis for the fourth strategy is cues-to-action, a component of the Health Beliefs Model. *Cues-to-action* "can be thought of as including any event or stimulus that triggers patients to perform the targeted behaviors" [58:30]. They are used broadly in HSM interventions, and may be as simple as sending participants reminders (e.g. a postcard or text message) to take some action. However, cues can also be internal to an individual: experiencing pain, or measuring an abnormal physiological measurement like elevated blood glucose. HSM interventions can help individuals reinterpret these internal cues to trigger positive target behaviors. Over time, this supports the user in developing a feeling of control over these internal cues, rather than ignoring or fearing them [58].

Monitoring applications are best suited to leverage the cues-to-action strategy. A system that monitors a user's physiological metrics can use abnormal readings as cues to encourage target actions that the individual is using to mitigate the problem. This may be an in-the-moment action, such as a reminder to take medication, or a broader behavior, such as offering to guide the user through a set of physical exercises or stretches.

Strategy 5: Allow Users to Increase Their Self-understanding through Small-scale Experiments

The fifth strategy that emerged from the analysis is the use of small-scale experiments to increase self-understanding. This strategy is a key component of the Blood Glucose Awareness Training (BGAT) program, a health self-management intervention that has been shown to be effective in improving the health outcomes of individuals with diabetes [24]. The BGAT program encourages participants to conduct small-scale experiments to directly observe the effect of stimuli (e.g. 30 minutes of exercise) on blood glucose levels. Through these experiments, participants are able to better understand their health condition and how it is affected by different actions and events. An individual with diabetes who has a better understanding of her body's responses to diet and exercise is better able to anticipate blood sugar level fluctuations [24].

The ability to run small-scale experiments can be integrated into applications that help individuals take steps toward healthy behavior change. In addition to the diabetes management example above, systems that support users in increasing physical activity through step count goals can allow users to investigate the number of steps involved in common activities—taking the stairs, walking around the block, etc. By helping the user build a better model of how different activities contribute to her goal, the user may be able to more effectively structure her day to include the desired behaviors.

Turning Strategies to Outcomes

I now turn to a discussion of open challenges to effectively integrating the above strategies into interactive applications. I focus on the operationalization of goal management strategies in interactive, computational systems, and on the need for systems that support small-scale experimentation.

Operationalizing Goal Setting Strategies

Health self-management interventions frequently use the first three strategies presented here together to construct action plans. This set of strategies seems to provide the most beneficial and coherent goal-management experience for interventions' participants. Effectively using these three strategies requires behavior change support systems to be able to work with users in setting short-term, actionable, and confidence-building goals.

Operationalizing these three strategies into computational systems that allow users to define and manage their own goals is an open challenge. One contribution of this dissertation is the presentation of how these strategies are operationalized in HSM programs. For example, the confidence-building strategy (Strategy 3) is operationalized by having the participant choose how confident she feels about realizing a goal on a scale from 0 to 10 [13]. It is also necessary to ensure that goals are both specific and actionable within the user's context. One way to establish whether a goal has these properties is to have the user annotate her goals with simple semantic metadata. Another way is to have the system include a human facilitator in the loop. The facilitator would be able to help the user set meaningful, specific and actionable goals related to her objective.

Supporting Small-scale Experimentation

Most behavior change applications described in HCI research literature do not support small-scale experimentation by their users. Instead, users are shown aggregates, such as daily or weekly activity levels. However, it may be useful for users to see the effects of individual activities in isolation. For example, an application that supports users in increasing their physical activity could allow users to compare the effect of particular, individual actions (e.g. calories burned by jogging in the morning vs. calories burned by always taking the stairs). This might help individuals plan their day better than would be possible if users have to rely on estimates of the activities' effects.

A challenge for such systems is to allow for data collection at a useful conceptual and temporal granularity, which may need to be context-specific and flexible. For example, Mamykina *et al.* reported that users of the MAHI system experimented with different meals to manage blood glucose levels [62]. However, there was a delay between making a dietary choice and seeing its effect on the blood glucose levels, which lasted between one and several hours. Small-scale experimentation systems need to be able to collect and present data on a time scale appropriate to the context. Additionally, systems that support small-scale experimentation need to allow users to analyze their collected data. In many instances, repeated measures are necessary to understand the effect of a stimulus. This analysis is currently most likely to happen with a human facilitator in the loop (as is the case in MAHI). However, there is also design space for automated or semi-automated sense-making interfaces that could support users in such an endeavor.

Completeness and Utilization

The list of behavior change strategies presented in this chapter is not intended to be exhaustive. Rather, it is a set of strategies that I have found in my literature review of health self-management literature. These strategies meet the three criteria presented at the beginning of the chapter; namely, they appear to be responsible for the success of health self-management interventions where they are used, they are general and can be applied broadly across the health and wellness domain, and they show the potential to be leveraged in interactive systems.

Only the first three strategies were used in the design and development of Salud! It is these strategies the effectiveness of which are evaluated in this dissertation. The additional two strategies are presented as worthy of potential future work.

CHAPTER 3

SALUD! HEALTH SELF-MANAGEMENT SERVICE STACK

There are two software systems that form a major research contribution of this dissertation. The first is a service stack (the Salud! infrastructure) that allows me, as well as other researchers, to easily develop and deploy health self-management applications. The second is the design and implementation of an applications for end-users that leverages this service stack (the Salud! application). The Salud! application will be further be expanded to include a goal management interface, which will be described in further chapters. It is the application that allows the design ideas behind the infrastructure to be evaluated through utilization by end-users. The availability of the infrastructure to other researchers allows a second-order evaluation, by looking at how well the services provided fit the requirements of health self-management systems conceived by other researchers.

I sought to satisfy two complementary goals through the design of the Salud! infrastructure:

1. To provide a set of easy-to-use web services that incorporate best practices and common paradigms for personal health informatics applications.
2. To provide a flexible, extensible set of personal informatics tools that can be customized by researchers to support a broad range of health-focused studies and interventions.

To achieve these goals, I developed Salud! in line with design principles culled from the literature about health self-management and personal informatics applications discussed in the previous chapter. Salud! is available to the broader research community as a set of web service APIs and associated applications.[1] In the following section, I describe the data architecture built into the Salud! infrastructure and the design principles which

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[1] A public wiki with documentation is available at http://wiki.cc.gatech.edu/salud.

guided this work. In the following section, I describe the Salud! application itself, and how the application utilizes the infrastructure to provide a health-focused, personal informatics tool to end-users.

The Salud! Infrastructure

The Salud! infrastructure and associated API allow researchers[2] to manage end-users and end-users' data for a custom personal informatics application. To better illustrate how the infrastructure works, I will describe how a fictitious, simple diabetes-oriented personal informatics application, DiabetesApp, could integrate with it. This application will allow an individual (the end-user) to register for an account, record her blood glucose reading, record one other variable she believes may be affecting her blood glucose levels (e.g. physical exercise), and review the historic values of the two variables overlaid on a graph.

All data stored on the Salud! infrastructure is associated with a particular end-user's account. Accounts can be created by end-users themselves through a simple registration page, or can be created programmatically by making an API call to the user management service. Data in an account is organized into structures called **Logbooks**. A Logbook is a named collection of timestamped data points. In the DiabetesApp example above, a user's account would contain a Logbook for blood glucose measurements and a Logbook for measurements of the other tracked variable. Each data point in a Logbook is called an **entry**. The simplest kind of Logbook consists of entries that only contain timestamps—for example, the approximate times when the account's owner visited the gym.

In addition to timestamps, entries in a Logbook usually contain other named values (called **columns**), that can contain numbers, text, and/or photos. A Logbook's columns

[2] In this chapter, the terms "researchers" and "developers" to refer to individuals who create applications that use the Salud! infrastructure, including myself. "End-users" to refers to the users of those applications.

are defined when it is created but can also be changed later to support evolving data collection needs. The base level of the Salud! service stack is a set of web services for managing users, and their Logbooks and entries, in persistent storage.

The second level of the Salud! infrastructure stack provides several human-usable services that facilitate data entry by end-users. Currently, all end-users can enter data into their own accounts via text messages, email, a smartphone application, and a web-based interface. Developers and researchers using the Salud! infrastructure can choose which services they make available to their group of end-users. They can also use the base layer of the stack to create custom data entry interfaces that fit their needs. In the remainder of this section, we will describe how various aspects of the design and architecture of the Salud! infrastructure can support personal health informatics applications.

Full documentation and sample source code to utilize the Salud! infrastructure are provided on the developer wiki at http://wiki.cc.gatech.edu/salud.

Table 3.1. Functionality provided by the two layers of the Salud! service stack.

Facilitator’s interface
Web-based data entry and analytics interface
Layer 3: Personal informatics application
Android and iPhonea mobile applications for end-users to create data entries
Email service for end-users to create data entries
SMS- and MMS-based services for end-users to create data entries
Managing and sending reminders for creating Logbook entries to end-users
Layer 2: Data Entry Services
Managing images associated with entries
Creating and managing data entries
Creating and managing Logbooks
Creating and managing user accounts
Layer 1: Core Web Services API

Primacy of Time-series Data

All data stored in a user's Salud! account is associated with a timestamp. This design decision leads from the importance of temporal relationships between variables in health self-management education. Helping individuals understand how physiological metrics are affected by behavioral and environmental factors is a key goal of health self-management education. For this reason, individuals participating in such programs are usually encouraged to keep logs of significant events and activities that may affect their health; for example, diabetics may keep track of their blood glucose readings and influencing factors such as diet composition and physical exercise [63]. Some educational interventions, such as Blood Glucose Awareness Training (BGAT), specifically encourage individuals to monitor temporal effects of stimuli, such as meals or exercise routines, on blood glucose levels over time [23].

Associating timestamps with all data also prevents problems that may arise from outdated information. End-users may only sporadically update their accounts with current data, in which case old measurements would only be valid for historical comparison and not for in-the-moment decisions (either by the user herself, or by any decision-support system which may also be accessing the data). Much physiological or behavioral data is outdated within days or even hours after its measurement (e.g. blood glucose readings, medication intake) and it so it is important to be able to account for the relevance of a data point before factoring it into any decision process.

Flexible Data Representation

The Salud! infrastructure provides a flexible data representation mechanism, which allows both developers and end-users to create Logbooks which track a wide range of data. This is to allow the greatest possible variety of systems to be built using the Salud! infrastructure. Columns in Logbooks can hold text and numeric data, photos, and data that comes from sets (list data). Columns of the list data type allow for a middle ground between quantitative data and free-form text. For example, if the developers of DiabetesApp wanted to allow end-users to track their food intake, they could use list columns to allow users to specify the meal ("breakfast", "lunch", "dinner", or "snack") as well as describe the contents of a particular meal, entered as a comma-separated list (e.g. "lettuce, tomatoes, croutons, low-calorie vinaigrette"). List columns work akin to tag lists on social bookmarking services, in that a vocabulary is built up from data values entered into that column.

Logbooks can be created and populated with data both by developers of Salud!-based applications and by their end-users. There are four ways in which Logbooks may be created for a particular application:

- **Starter Logbooks**, created by developers for all end-users of an application. These may include "Blood Glucose Readings" for users managing diabetes, or a Logbook to track use of rescue inhalers for users with asthma. These Logbooks may also be automatically populated with data (more on this below) and users can be prevented from editing their data (if needed).
- **Optional Logbooks**, which are made available to end-users of an application to add to their account if they want. For example, in DiabetesApp the second variable to be tracked may be selected by each user from a list of available options.
- **Personal Logbooks**, which are created by end-users to track personally-relevant information for which Logbooks are not provided *a priori*. This may include Logbooks which track personal metrics like stress, time spent with family or friends, particular recreational activities, or any other type of activity or behavior in which the end-user is interested. Because Logbooks can contain a variety of columns (or none at all), end-users are able to track variables in a way that is personally meaningful to them, instead of relying on pre-set or hardcoded templates.
- **Facilitator Logbooks**, which can be created for a particular end-user by her or his account facilitator. Facilitators are expert end-users who have access to other end-users' accounts. They may be specialists like personal trainers, nutritionists, or nurse practitioners who are helping or monitoring a client. Logbooks created by facilitators may be more appropriate than Personal Logbooks for users who are not comfortable or sophisticated enough to establish their own data entry structures.

In most cases, end-users can also edit existing Logbooks to better serve their needs. For example, a user who is automatically provided with a Logbook for tracking meals can add additional, personally-relevant columns, such as where the meal was eaten, how it tasted, etc. When necessary, however, researchers or developers can prevent end-users from editing specific Logbooks—for example, if the Logbook's data comes from an automated service.

The Salud! infrastructure also explicitly allows incomplete data entries. Only a timestamp needs to be initially provided to create a new entry in a Logbook—all other columns (if any) can be populated at a later time. This functionality is meant to encourage prompt and accurate logging. At the time of an event or action that is being recorded (e.g. a meal, or an occurrence of chronic pain), an end-user may not have the time or desire to fill out a complete Logbook entry. In this case, she may choose to create only a minimal entry, noting only the time and possibly adding a picture (e.g. for a meal). Such entries can serve as placeholders and reminders until the end-user has more time to review them and input additional data.

Support for Images

Multiple studies have shown that photos can serve as important educational and reflective tools for individuals learning health self-management. For example, a photo of a meal can help an individual better recall the composition of the meal, as well as reflect about whether and why the meal was a healthy or unhealthy choice [62]. Photos of meals can also be shared with educators and peers to spur important discussions about eating patterns and dietary choices [34,82].

Additionally, photos make it easier to remember the context of a particular situation and may be more engaging than simple text for some users. Taking a photo of a meal with a smartphone (see Figures 3.7-3.8), or sending an MMS to a dedicated phone number, is an easy way to track eating habits. The details of the meal—calories, contents, etc.—can be filled out at a later time by using the photo as a memory aid.

For these reasons, the Salud! infrastructure allows Logbooks to contain image columns, which permits end-users to associate photos with individual Logbook entries. The infrastructure handles the storage, resizing and retrieval of the images, so developers and researchers can incorporate photos or other images into their personal health informatics applications with less effort.

Data Entry Layer

The second layer of the Salud! service stack is a set of data services that end-users can use to add data to their accounts. These services can be complemented by bespoke solutions created by other developers and researchers for their needs. I have developed several data entry applications to try to accommodate the preferences of a majority of common user types. Currently, individuals with Salud! accounts can create entries in their accounts via email, SMS/MMS messages, using a smartphone application (see Figures 3.7-3.8), and a Flash-based online interface. In order to use the email and text message services, an email address and mobile phone number must be associated with the user's account, respectively. There is an additional service (also accessible via an API) for managing and sending data entry reminders to end-users. Currently, reminders are sent as text messages and can be scheduled to be sent daily or weekly at specific times of the day. Researchers building applications on top of the Salud! infrastructure can choose to inform their end-users of these data entry options, or opt to develop custom data-entry mechanisms that suit their needs.

Automated Data Entry

The availability of data entry management web services in the Salud! infrastructure makes it straightforward to develop both automated and interactive data entry services for specific needs. Researchers can also request special system-level authentication tokens, which allow their applications to add or retrieve data from their end-users' accounts without requiring an interactive login. This functionality enables the creation of services that automatically populate data into end-users' Logbooks. For example, one research team used the Salud! infrastructure to develop a personal health informatics application for families with children with asthma. The service regularly updated a Logbook with outdoor air quality data from sensors in the families' neighborhoods [91].

Services could also be developed that allow end-users to enter personal data via Twitter posts, instant messages, etc. We believe that this flexibility makes the Salud! infrastructure a viable service stack for a wide range of potential personal health informatics applications.

Privacy and Security

The security and privacy of the data stored in the Salud! infrastructure is of paramount concern. All data is stored on a secured machine in a secured, on-campus location. Backups are created regularly to minimize the chance of data loss. Communication with the web services that make up Salud!'s API happens over secure (SSL) connections. End-user logins are handled securely by an open-source, industry-standard system (Drupal). Only individuals directly affiliated with on-going research are provided with authentication tokens that allow them access to appropriate end-user data. A privacy policy for end-user is also provided via a link from the Salud! homepage.

The Salud! Application

The very top level of the Salud! service stack, is the Salud! application, which implements full, end-user access to the functionality offered by the Salud! infrastructure. The Salud! application is a web-based personal health informatics application aimed at a broad range of end-users. As a stack component, the application is also available as the default user interface for researchers wishing to utilize the Salud! infrastructure without creating a custom UI.

Data Entry and Review Interface

The application allows end-users to track daily activities, events and measurements, as well as to review and analyze the recorded data. Upon registering for an account, new users can select from a set of Starter Logbooks to add to their account. These Logbooks are designed for tracking common health and wellness metrics, such as blood pressure, sleep, and weight (see Figure 3.1). After this step, users can create custom Logbooks in which to track other variables of interest to them (see Figure 3.3). The online application provides a data-entry interface, but users of the Salud! application can also create entries in their Logbooks via the other data entry services discussed above (e.g., text messages, smartphone application, etc.).

Once recorded, entries are displayed on a visual timeline. If a Logbook contains numerical columns, these are plotted along the y-axis (see Figure 3.2). Otherwise, entries in the Logbook appear as points on the timeline. This allows users to view temporal fluctuations in numeric variables or spot patterns in the frequency of events. Additionally, it is possible to view aggregate temporal data by summing or averaging over daily, weekly, or monthly timeframes (see Figure 3.4).

Analytics Interface

The application also provides an analytics interface where data from different Logbooks can be viewed side-by-side, to look for patterns or trends. This interface allows end-users (as well as facilitators) to simultaneously view data from several different Logbooks, and thus explore relationships between activities, behaviors, health data, etc. Users can drag specific columns from Logbooks into the visualization interface to display their data side-by-side, or stacked, with data from other Logbooks (see Figure 3.4). As with the Data entry and Review interface, this interface provides aggregation functionality to examine trends over different timeframes.

A significant amount of effort has gone into making this interface intuitive and useful. The timelines of all graphs are always aligned, so that it's visually easy to establish or confirm temporal patterns. I have implemented robust axis-numbering logic that provides clear data views for a wide variety of possible data ranges (from medicine dosages measured in fractions of a gram to step counts measured in the tens of thousands) [47]. The analytics application also automatically detects when values from two different columns should be displayed on the same y-axis (for example: systolic and diastolic blood pressure, or calories consumed and calories burned).

The analytics interface provides simple aggregation and visualization tools. This allows users to review sections of data collected across long timeframes (the lowest granularity available is a single month view). Aggregation features, such as summing and averaging, allow users to create trends out of noisy data points (e.g., weight measurements averaged over a week give a clearer trend than a series of noisy daily measurements).

In the future, we expect to integrate novel health self-management interfaces into the Salud! application, to evaluate their effectiveness. We are also exploring options for making this application more customizable and platform-like so that other researchers could use it as a foundation for their own applications.

Facilitator Interface

One of the key features of the Salud! application is the ability of users to share their account information with facilitators. *Facilitators*, who are usually domain experts such as nutritionists, personal trainers, etc., provide four benefits to their Salud!-using clients: (1) assistance in setting up relevant and evidence-based Logbooks, (2) entering data that may require specialized equipment or knowledge (e.g. BMI or girth measurements for weight-loss clients), (3) assistance in interpreting the patterns in collected data, and (4) required input into Salud!'s goal evaluation interface, described further in this dissertation. The presence of a facilitator interface (and the ability to enable and disable it for various deployments) allows the system to be used in a wider variety of real-world behavior change and goal management contexts than would be possible otherwise.

Facilitators access the Salud! application through a separate facilitator portal. Their interface to Salud! includes a client list (see Figure 3.6), which they can use to browse the data of the different individuals with whom they are working. When a facilitator selects a client, she sees the Salud! interface as it would be seen by the client herself—including all of her Logbooks, entries, and the analytics interface. Thus, the facilitator can create Logbooks on a client's behalf, enter data into Logbooks, and review and analyze data stored in the account.

In addition to the standard data view, facilitators are provided with two additional features. They can "lock" certain Logbooks, preventing users from directly editing its structure or the entries in it. This may be required for Logbooks that are updated by automated services (e.g. [91]), or if the data entries must be officially vetted by the facilitator. For example, personal trainers participating in Georgia Tech's Biggest Loser fitness competition [36] used locked Logbooks to track their clients' scores and weigh-ins to ensure accuracy and fairness during the competition. Facilitator input is also required if clients wish to use the goal management tools embedded into the Salud! interface. Because goals can range in type and structure, as well as require periodic evaluation, facilitators must apply their expertise to manage goals that are not specifically programmed into the application. A thorough discussion of the goal management interfaces, as well as facilitators' role in this interaction, will be presented in Chapter 5.

Other Features

The Salud! application has been in continuous development for over three years, and a multitude of individual developers and designers have contributed to its codebase, functionality, and design. Some of the features that have been developed have helped to attract and retain users. Some were developed to meet personal needs, or satisfy curiosities. Some were research or design experiments that sought to evaluate the potential for future work. In this section, I will describe some of the most visible and used features of the Salud! application that do not otherwise strongly contribute to the specific research agenda presented in this dissertation.

The discussion of these features serves two purposes. First, it highlights the breadth of functionality that may be implemented on top of the Salud! service stack. Second, it provides additional context for how users of the Salud! application perceived and interacted with the application; the options which were available to them. Personal informatics can be a tedious and time-consuming task. As such, my goal as a designer was to make the application as engaging and exciting for the end-users [70], without losing sight of the resource limitations available to the project, or its main research goals. Understanding these additional features should provide additional context for the reader to holistically evaluate participants' overall experiences.

Reminder scheduling

The second layer of the Salud! service stack provides an API for data entry reminders. This feature is also accessible to end-users via a Reminder management interface in the Salud! application (see Figure 3.5). Users can set and manage multiple reminders to be sent to them via SMS and email. Reminders belong to the set of features that encourage and enable end-users to store accurate, timely data in Salud! Accurate and timely data entry is useful for both the end-user and for the researcher.

In Figure 3.5, the user has multiple reminders set to assist her in accurate and timely logging of her meals throughout the day. Two reminders—for breakfast and dinner—

arrive as text messages in the morning and the evening. Lunch reminders for weekdays are set to arrive via email in the middle of the day—where the user feels she is most likely to respond to them (as she is more likely to notice and respond to emails while at work). When a reminder arrives, the user can reply directly to the reminder to add an entry to the specified Logbook (though the system is not sophisticated enough to auto-recognize the desired Logbook; it must still be provided as part of the SMS/email message). Of course, the user is also welcome to enter data without reminder prompting.

The reminder interface is also available to facilitators. They can pre-populate a reminder schedule that they feel is appropriate for their clients. Facilitators also have the option of changing the reminder text—providing personalized contextual or motivational messages, for example.

<u>Starter Logbooks and Logbook Templates</u>

One of the main problems noted during early, informal evaluations of the Salud! application was the “emptiness” of new user’s account. Until the user (or her facilitator) populated her account with Logbooks, the interface was bare and did not provide obvious starting points for successful, engaging interaction. Curious users without a clear personal informatics need would create an account, look around, but soon leave because the barrier to creating a structured data entry template (Logbook) was cognitively high.

To mitigate this problem, I added several ways for users to immediately populate their account with Logbooks. During the account creation process, all users are provided with a short list of common Logbooks they can immediately add to their account: Weight, Sleep, Energy Level, etc. (see Figure 3.1). In addition to making the account less “bare,” these basic Logbooks allow the user to begin building a mental model of how to construct effective, personally useful Logbooks.

When users decide to create new Logbooks, they are also provided a set of template Logbooks, which can be selected and modified based on the user’s needs. Similarly to Starter Logbooks, one of the primary reasons for Logbook templates is to help the user consider her data collection goal in structured terms that can be implemented as a Logbook. Informal usability studies of the Salud! application showed that most potential users (especially those without a background in system, process, or metric modeling!) are not used to thinking of data collection in structured, quantitative terms. Template Logbooks provide users with models for how to conceptualize common data collection needs in terms that Salud! can help them track and analyze.

<u>The Logbook Store</u>

The Logbook Store was an experimental feature that was designed and prototyped to expand the utility of template Logbooks. The idea was to provide an App Store-like environment where end-users could add external Logbooks to their account. Logbooks could either be static—such as specific templates uploaded by other users—or backed by an automatic data entry service.

Adding automatic data entry services to Salud! was seen as a way to make the system more engaging; users could both enter manually enter data as well as have automated data streams the could use for analytics and pattern purposes. Proposed data services included “smart” personal health equipment (such as the Withings Digital Scale), other health related services (such as Fitbit), and public data such as local weather, pollen count, etc.

Several of these services were added as one-off Logbooks available to a subset of users. I then worked with several Master’s students to design an architecture that could allow designed developers to add their own Logbooks (and backing data services, if desired) to the list of available Logbook templates. The architecture took into account developer authentication, limiting services’ access to account data, the API which would be used to create service-backed Logbooks, user-specified settings for service-backed Logbooks (e.g. how the user would provide their zipcode to a service populating a Logbook based on local outside temperature), as well as how those services would then push data to the accounts of those users who added the Logbook to their account.

A basic version of the Logbook Store was operated internally by the Salud! team during a semester-long development cycle. It included basic service-backed Logbooks such as local weather and stock price. However, due to the lack of a user-friendly interface for the setting of personalized settings, this feature was not made available to the entire community of Salud! users.

Data Export

The Salud! service stack provides a data entry and retrieval API to storing personal data. The Salud! application and related services then provide a way for end-users to enter personal data into their account. In its initial stages, there was no simple way to extract data from a Salud! account, or share it with others (other than a facilitator).

The Salud! application now provides several ways that users can share data with others. One method is to easily save on-screen graphs (e.g. in the analytics interface) as image files. These can then be shared with an expert (e.g. during a visit to a physician), or even uploaded to a blog or forum—whether to brag about progress, or to clarify a question. The second method allows the user to print a spreadsheet-like view of a specific Logbook. This method is more appropriate for providing healthcare providers with data, such as sharing a list of self-recorded blood pressure entries with a physician.

Finally, a feature in the Salud! application allows users to export their Logbooks as comma-separated value (CSV) files. These files can then be imported into Excel, another online personal informatics application, etc. This feature ensures that users are not “locked in” to Salud! and can easily delete their account or switch to a different application without potentially losing valuable and important personal data.

Facilitator Chat

An experimental chat feature was deployed in conjunction with the GT Biggest Loser study (see Chapter 4). A specially reserved “Chat” Logbook was available to both clients and facilitators to send asynchronous messages via entries. When one user (e.g. the client) creates an entry in this Logbook, an email notification is sent to the other user. Instead of burdening the user with the message immediately, it contains a link that opens the message when clicked. The notifications also come no more frequently than once an hour. This allows for a more low-key interaction between client and facilitator than more immediate communication media, such as direct email.

Facilitator Daily Summaries

Another feature developed to assist facilitators in managing their clients are daily email summaries of client activity. Facilitators can opt to receive a daily digest of their clients' activities: which clients were active, and into which Logbooks they entered data. This feature allows facilitators to keep up with a fairly long list of clients without having to constantly login to Salud! and review each of their Logbooks for new data. During informal formative design sessions, facilitators expressed a stronger preference for email summaries than in-app notifications of new activity (e.g. badges by active users or updated Logbooks). Facilitators noted that they constantly monitor email, whereas they would prefer not to login to Salud! if they don't otherwise have a need, only to check whether a client has been active. These daily summaries serve the key research function of keeping facilitators engagend and involved in their clients' use of Salud!

Additionally, email summaries provide facilitators with a high-level view of active and inactive clients, as well as data entry practices among clients. Facilitators can use these to keep track of which clients need additional encouragement to enter data, and which clients may be entering data "in bulk" (e.g. at the end of the week) rather than consistently. The later data entry practice needs to be monitored, as it can be influenced by hindsight bias or selective memory [7].

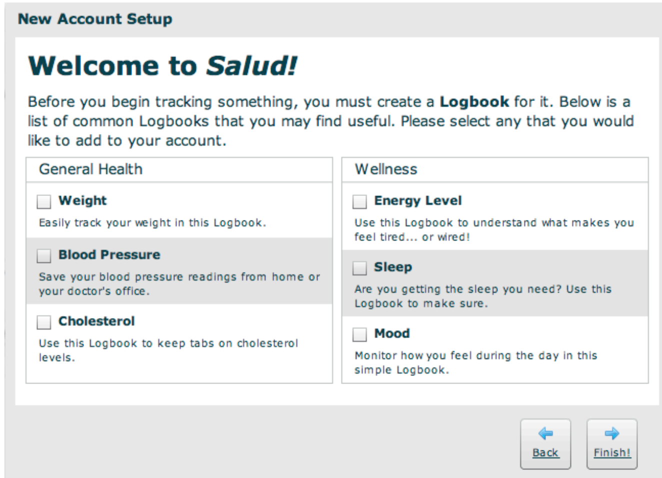

Figure 3.1. Portion of the Salud! application's account creation process, showing starter Logbooks offered to end-users.

Figure 3.2. A portion of the Salud! application's interface, showing an end-user's self-reported weight measurements plotted on a timeline.

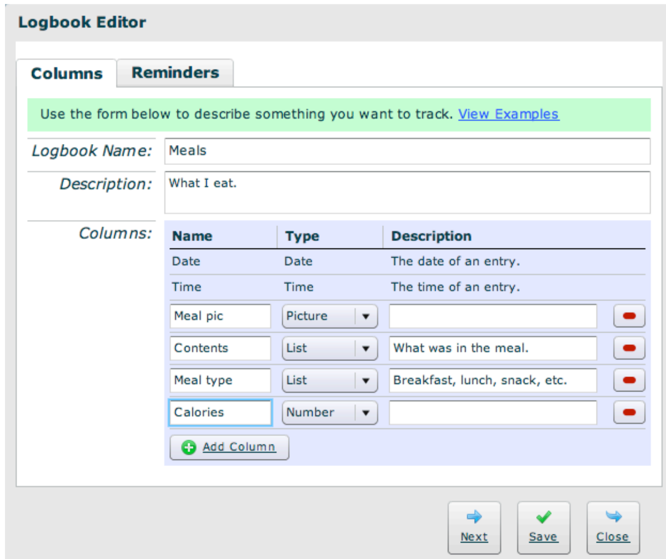

Figure 3.3. Example of a Logbook created by an end-user of the Salud! application

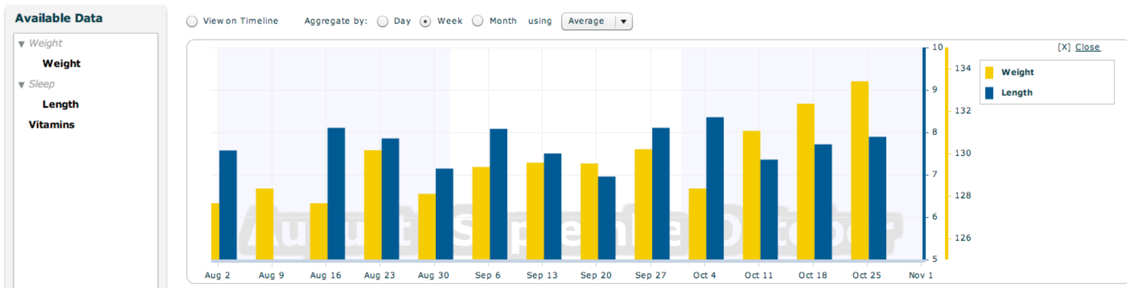

Figure 3.4. A portion of the Salud! application's analytics interface for end-users. Two columns from different Logbooks are shown on the same graph.

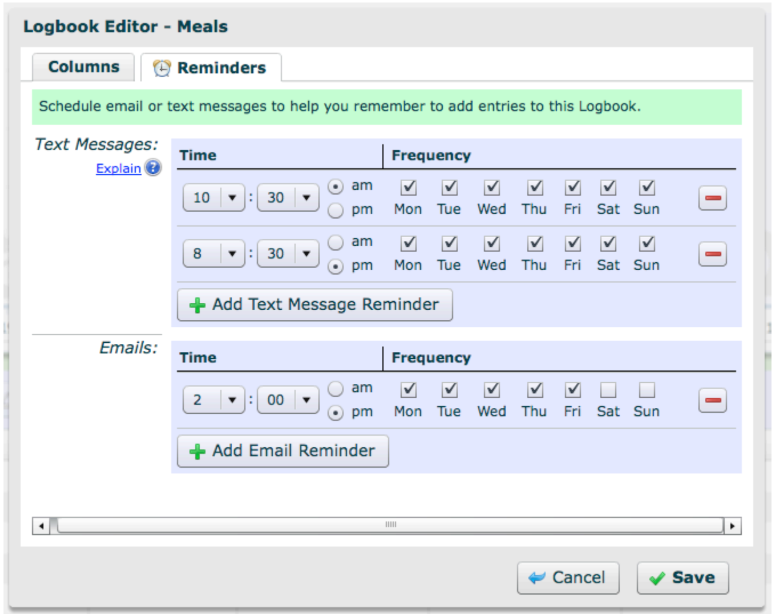

Figure 3.5. Reminder scheduling interface.

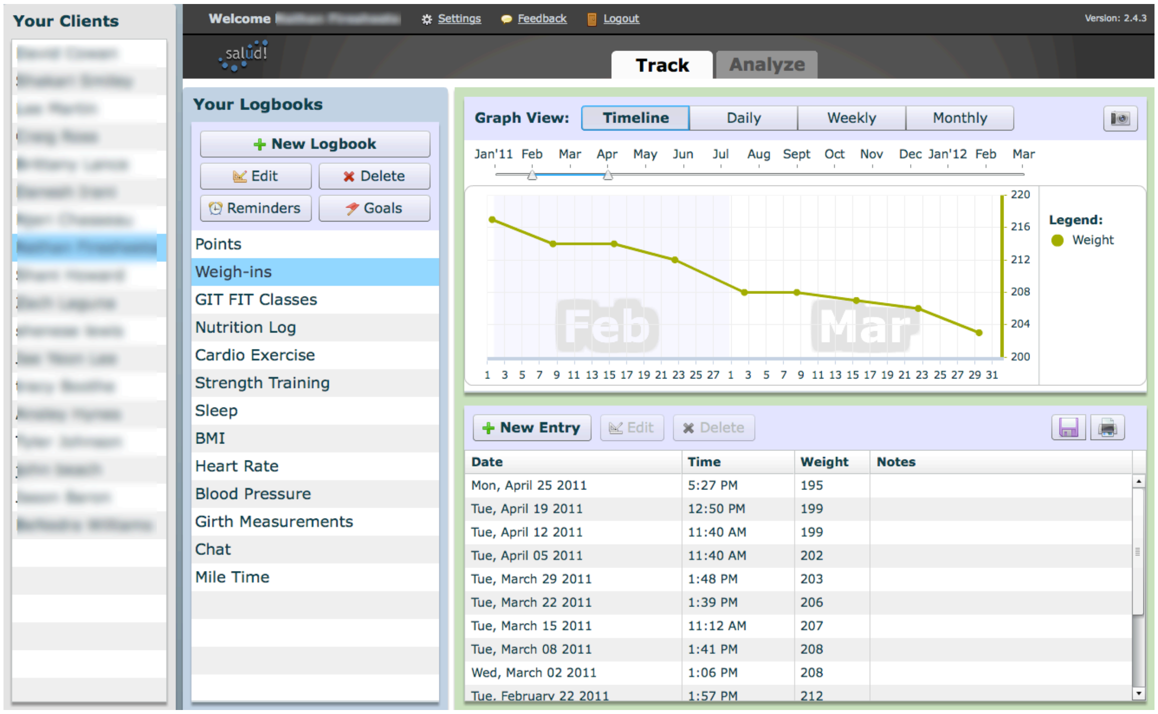

Figure 3.6. The Salud! facilitator interface. The left column lists the facilitator's clients. The selected client's Logbooks and entries appear in the main section. The analytics interface for a particular client is available through the Analyze tab. Names have been blurred for anonymity of study participants.

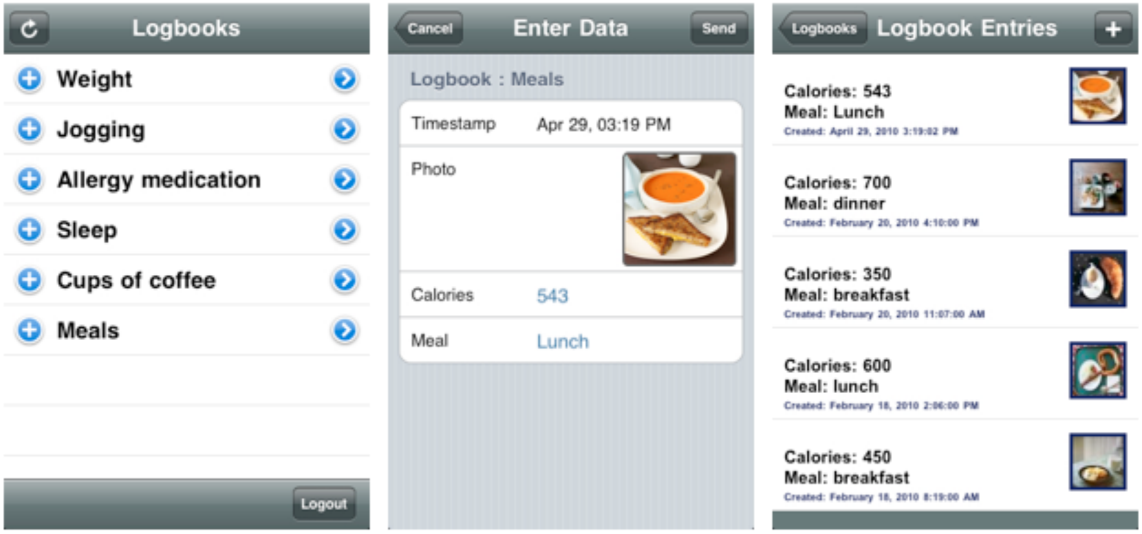

Figure 3.7. iOS Salud! application interface. The first screen shows a list of the user's Logbooks, as well as buttons for reviewing data and creating new entries. The second screen shows a new entry being created for a "Meals" Logbook. The third screen shows the newly created entry in the list of all entries in that Logbook.

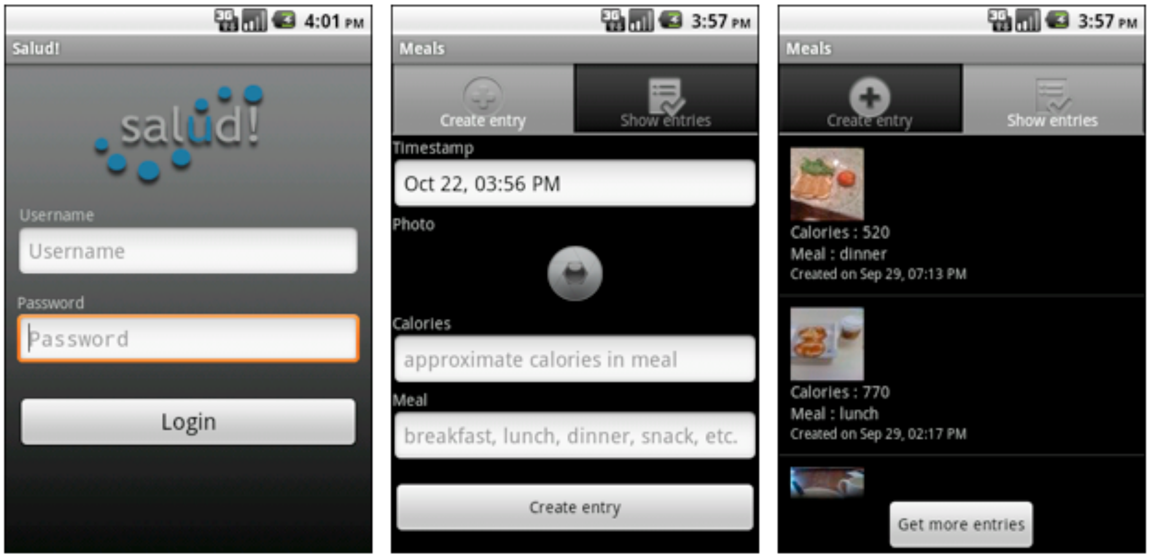

Figure 3.8. Android Salud! application. The first screen shows the login screen (to minimize data entry effort, login information is saved and the user is logged in automatically after an initial login). The second screen shows a new entry being created for a "Meals" Logbook. The third screen shows the newly created entry in the list of all entries in that Logbook.

Evaluation and User Feedback

Both the Salud! application and the service stack received significant attention and use from a host of users. In this section, I first present an evaluation of the Salud! service stack, based on comments, feedback, and requests from individuals (predominantly other Georgia Tech researchers) who used it, or attempted to use it, as part of their own work. Then I present details of how the Salud! application was adopted and utilized by end-users. Because of its broad flexibility, the application was used for a variety of purposes. I focus my discussion in this section on how its features were utilized for the purposes of goal management, behavior change, and related activities (such as self-tracking practices).

Salud! Service Stack

I advertised the Salud! service stack to researchers at Georgia Tech and other institutions through word-of-mouth, presentations, via information on the public Salud! website, and at several relevant conferences [51,66,67]. All together, the infrastructure was utilized by more than 10 different projects, with about a 50/50 split between small, short-term projects (like class projects) and larger, longer-term projects that led to publications or other substantial deliverables. Several research groups setup a full image of Salud! on their own infrastructure, rather than using the public services available at http://GTsalud.org. Reasons for this included the need to ensure privacy/security of participant data, and requirements that may have required code changes to the underlying application.

The most common use of the Salud! service stack was as a data store for the output of medical or home-based sensors (6 projects). The second most common use of Salud! was as a data store and visualization system for participants in research studies (3 projects). Other, one-off uses included the design of a discussion platform around personal health/medical data, and an off-the-shelf diary for medical practitioners. One student used the Salud! backend to store real-time data about on-campus transportation.

The three layers of the Salud! service stack were designed to be modular, and could be used independently. However, actual use congregated around the lowest and highest layers of the stack. Most users of the stack used only the lowest level, creating their own input and, if necessary, output/visualization services that integrated with the data and user management API. Many of these users used the Salud! application (top stack level) for review or debugging, but not as part of their production functionality. A second group of users deployed the Salud! application, by itself, as an off-the-shelf personal informatics tool. All of these deployments made use of Starter Logbooks to create customized accounts for participants that fit their study requirements. Two users of the stack used both the lowest level and the top level: they created custom input/visualization services for their participants, while also allowing their participants to use the full Salud! API as a full-featured data review and analytics tool.

The middle level of the service stack was notably absent from any third-party use of the Salud! service stack (I used it regularly as part of the studies I will describe later). When I developed the middle layer and made it publically available, I considered that it could be used for a broad range of purposes. Mobile data entry, a data reminder API, and email services seemed useful for a wide range of tasks and end-user deployments. However, none of the actual Salud! service stack users made use of any of these services (there were also no inquiries about these services by potential third-party users). Users of the stack fell into two categories: those where the end-user/participant had no interaction with the data stored in Salud! (e.g. low-level sensor data), and those who created similar, custom services (e.g. a different SMS-data entry method) because of rigid design constraints on their work.

The most common feedback from outside users of the Salud! service stack regarded the Salud! application. Because I had designed it to be a generic personal informatics tool for common kinds of health and wellness data, it was frequently inappropriate for specific uses. For example, the human-scale granularity of the data visualization (hours, days, weeks, months) prevented it from usefully displaying high-frequency sensor data [27]. Viewing ordinal or categorical data, as well as Logbooks that consisted of many numeric columns, was also awkward. Thus, by designing a “general purpose” end-user application, I had really designed for what I considered “general purpose,” which meant data collected at intervals of several hours to several days, with at most two or three numeric fields (or, conversely, only text data), and maybe a photograph. This turned out effective for data such as weight, calories, basic exercise (e.g. jogging, cardio), but was not nearly "general" enough to encompass the variety of data other personal health informatics researchers work with daily, such as sensors [88], or structured reports [45].

Evaluation of the Salud! API

This subsection presents an informal evaluation of the Salud! API, which is the developer's gateway to the functionality provided by the lowest level of the Salud! service stack. While the middle stack layer also provides API services, including reminder management and goal management (discussed later), these APIs were not used by third-party developers, as noted above. Recently, there has been substantial interest in API usability as a subfield of HCI [26]. Several API-specific usability evaluation methods have been proposed in the past two years, based on peer review [28], usability testing [84], and concept maps [37]. The majority of this work came out after the bulk of the Salud! API had been built. Also, this dissertation was not intended to be a formal usability analysis; the evaluation presented here is based on user feedback, and concerns both the usability of the API as well as its practicality for user needs.

I implemented the Salud! API as a set of stateless web services. While I tried to follow RESTful design principles [29], the API is not fully RESTful for two major reasons:

1. The API does not use the full vocabulary of HTTP methods (GET, PUT, POST, and DELETE) and return codes.
2. The API methods use an additional nomenclature of verbs and nouns, instead of interacting with entities using URIs and HTTP functionality. For example, to retrieve a list of a user's Logbooks, one calls `GET [salud_url]/getLogbooks?userID=X` instead of `GET [salud_url]/userID/logbooks`.

Indeed, the sematics of account access control via function parameters caused some initial confusion for some developers. Because the API was to be stateless [72], and because managing cookies is more complex than managing query parameters in many common web libraries (e.g. Java, PHP), API users had to provide authentication tokens as part of every API call. The semantics of the token-based authentication (there were two distinct types of tokens, with different access privileges), combined with the data semantics (e.g. getLobooks, getEntries, getEntryDetails, etc.) made the API awkward for some novice programmers. However, by providing sample code in PHP and Java, for both obtaining access tokens and making common API requests, I was able to provide a simple-to-use guide through the first several steps.

I chose XML as the data representation for the Salud! API because of its readability (by humans), familiarity to many developers, and because its nested node structure was a good semantic fit for Logbooks, their columns, and the temporal data streams they described. However, XML presented two challenges for developers:

1. Developers unfamiliar with their development environment's XML libraries faced challenges traversing the sometimes-complicated XML documents passed around by the API.
2. Some developers created XML documents through string concatenation, which meant that they did not escape special XML characters, causing their requests to fail if given data with quotes, ampersands, or comparison operators (<, >).

In spite of these challenges, none of the service stack users reported being frustrated or overwhelmed by the use of XML as the data representation. All had at least some familiarity with it, and appreciated its use as an industry-standard for data representation. In future versions of the Salud! API, however, I would recommend offering several options for data representation (e.g. JSON, XML, and even human-readable plain text), which can be selected by the developer by setting the Accepts-Content HTTP header, or using a data presentation selector (e.g. `GET [salud_url]/userID/logbooks.json` or `GET [salud_url]/userID/logbooks.xml`).

<u>API Functionality Coverage</u>

Applications that compose much of the middle and top layer of the Salud! service stack are web applications or mobile applications. Because of this, they have no direct access to Salud!'s data store through network connections or direct I/O. As such, I needed to build API endpoints for each piece of functionality to be made available to Salud! end-users. For this reason, the Salud! API offers complete coverage of the functionality available in the Salud! backend (lowest layer). Any operation that is available to the Salud! application or any of the mobile applications is also available, via API calls, to developers who may be interested in appropriating them. My most common strategy for releasing new Salud! features was to create the API and end-user frontend, deploy the new frontend functionality to ensure that the backend could handle real use, and, once the backend functionality was shown to be stable, to document the API calls publically, so that they could be used by others.

Conclusion

The zeitgeist of service-oriented software infrastructures has shifted significantly in recent years. For a long time, computing infrastructure consisted of middleware and software frameworks, used predominantly for enterprise computing [11]. Now, software infrastructure is much cheaper and available to a broad range of end-users as cloud computing services [2,44]. Both of these software service paradigms are aimed at professional application developers.

The Salud! service stack is unique in that is closer to being goal-oriented than strictly service-oriented. Its objective is to provide tools that enable personal health informatics researchers to accomplish their work more easily and effectively. For this reason, it provides distinct service layers that can be used both by developers and non-developers for a range of goals. Thus, it is more closely aligned with Bernstein's notion of a framework [11] than with a cloud computing utility, with the caveat that the framework is hosted externally. However, it also bears resemblance to cloud-hosted applications that have rich APIs, such as Google Docs. Such applications, considered both for their end-user product as well as their APIs, are not yet being studied and evaluated by HCI researchers. This intersection of functionality would be a natural way to combine the recent interest in API usability with HCI's traditional emphasis on products for end-users.

Salud! Application

In this subsection, I present use data and user feedback for many of the features included in the Salud! application, as described earlier in this chapter. The focus of this section is to describe how the various features were utilized with respect to data entry practices. This overview provides the context for subsequent chapters, where I discuss how data entry practices ultimately affected goal management and realization. Many of the themes started in this section are continued in greater depth in Chapter 4.

Since August 2009, over 500 individuals created a Salud! account and went on to make at least one data entry. This figure includes approximately 200 study participants. The balance consists of individuals who learned of the application through word-of-mouth or media attention. These users entered data into a combined total of 1700 Logbooks that together hold approximately 50,000 user-entered data points. The total number of data points stored in Salud! is 1.5 million, but the vast majority of these were created in a handful of Logbooks, by automated data entry services from high-frequency sensors. Nonetheless, the total volume of data shows that the infrastructure is scalable.

Data Entry and Analytics Interfaces

All users logged into the web-based Salud! application to setup and begin using their account. However, the majority of users to whom I spoke or who otherwise provided feedback noted that they spent the vast majority of their time in the data entry section ("Track" tab) and rarely, if ever, used the analytics portion of Salud! (the "Analyze" tab). The rationale that users articulated was that they had a good mental model of their own data, and so could update it by clicking through each of the Logbooks in their account in the Track tab (see Figure 3.6). Most users cited no additional benefit from plotting their data together in the Analyze tab.

> I mostly looked at each [Logbook one] at a time. I didn't log weight that often mostly because there wasn't much of a change. So just to see that line kind of going, you know, so I knew what that was. –*P3* [3]

Those users who used the Analyze tab did so relatively infrequently. The predominant reason was to get a different perspective on the data, or to validate hypotheses about their performance.

> I did go to the analyze tab, but not very often. I just wanted to see what it looked like to put workouts and weight together or workouts and food calories to kind of see time, how much time I was doing my workouts. I also when I did that tried to think about how many calories I was burning those workouts to kind of have that

[3] Participant codes are introduced in Chapter 4.

> comparison. So it was much more I guess in my head, but I did go to the analyze tab a few times and put things together. *–C9*

Facilitators were much more likely to use the Analyze tab to review their clients' performance. Because they were not as intimately familiar with a client's data as the client herself, the Analyze tab allowed them review key data streams in an account together and catch up to recent activity. There is further discussion of how Salud!'s analytics tools were used in Chapter 4.

Mobile Data Entry

Entering data via mobile phone—SMS, iPhone app, or Android app—was essential to some Salud! users. Though I had initially intended the mobile applications to be simple data entry tools, most users of the apps requested the ability to review data in their account. They specifically indicated a preference for chart views, as in the full-featured online application. However, the lack of an easy-to-use charting package for mobile environments at that time prevented me from providing anything more sophisticated than a table data view. Bug reports about mobile application stability (especially on iOS) formed one the largest clusters of user feedback. This method of entering data was a key practice of some Salud! users, and if they were unable to enter data on their mobile phone (e.g. due to a buggy release) they would generally stop entering data.

However, some users for whom mobile data entry was available (e.g. through an unlimited texting data plan or ownership of an iPhone/Android smartphone) rarely entered their data in that way. Instead, they preferred to log on to the Salud! website, and enter their data using the online application. These users generally tracked a wider variety of personal data, and also were much more likely to enter longer notes or other text data into their Logbooks. Users in this category reported being more reflective during data entry than users who entered data via their mobile device. This theme is further developed in Chapter 4.

Reminder Services

The ability to schedule data entry reminders was a later addition to the Salud! application. Those who used the feature clustered into two groups. One type of user would set reminders, but eventually learn to ignore them. In some cases these users would turn off the reminders, but more frequently they would keep receiving reminders long after they had stopped using Salud! at all. A second type of user focused all of their data entry for a day around a single reminder. Thus, even though the reminder technically came for a single Logbook, they treated it as a prompt to update their entire Salud! account.

> I would click on that [reminder] email and input what I was planning to do that day. So if I knew that I was going to go on a half an hour run this afternoon with my dog, I would just go ahead and put it in. I would also enter what I did yesterday. If I didn't have anything on the calendar to do but I ended up doing something I would put that in the next day. *–P3*

Facilitator Interfaces

Facilitators were in a unique position to view and sometimes enter data into multiple accounts. Because these accounts contained their clients' data, they were not as intimately familiar with the accounts' contents. Salud! initially did not have any way of highlighting Logbooks with new entries, and so facilitators had to click through each client's Logbooks to check for new data. I introduced daily summary emails for facilitators to rectify this problem. The emails noted which Logbooks each client had entered data that day (if any), so that facilitators could more quickly locate new data. However, to encourage engagement with Salud!, the summary emails did not contain the data points themselves, instead providing links to the updated Logbooks. Even if a facilitator did not check new data daily, the summary emails provided her with cues about which of clients were actively engaging with the application, and how frequently. This allowed for conversations about data entry (or lack there of), and whether it was part of a broader lack of engagement with the fitness program.

Developing the facilitator interface and associated features provided an interesting implicit critique of the Salud! application's data UI. The facilitators' experience showed that the UI was implicitly designed for individuals to perform manual data entry of their own data. Without knowing oneself, it is difficult to tell if a Salud! account, or any of its Logbooks, have been updated. Personal informatics tools that expect to share data between multiple users should accommodate the fact that other users need cues to help them follow data that is not theirs.

Toward Goal Management Interfaces

This chapter discussed Salud! as a personal health informatics application, as well as how its features affected users' data collection and self-monitoring practices. In the following chapter, I move from self-monitoring to gather real-world requirement for goal management systems. To accomplish this, I deployed Salud! in personal training contexts and observied its use as a personal informatics tool by individuals (and trainers) already engaged in practices of behavior change and goal management. As the participants transitioned their practices into Salud!, I was able to record these practices and also prompt the participants to articulate their experiences.

CHAPTER 4

TWO FIELD DEPLOYMENTS OF SALUD! IN FITNESS CONTEXTS

This chapter presents the furthering of the requirements gathering process for a goal management interaction that can be integrated into a general personal health informatics application like Salud! So far in this dissertation, I have presented theoretical foundations for an effective goal management interaction (Chapter 2), as well as a personal informatics tool upon which interactive support for goal management can be built (Chapter 3). The next step in the design process was to analyze real-world behavior change and goal management practices, in order to understand different types of goal articulation strategies, self-monitoring practices, and the role of a facilitator in the goal management/behavior change process. This would help me to anticipate end-user needs for the goal management tool, so that it would not simply overlay an abstract set of interactions over real-world behavior.

Because goal management and behavior change strategies may be ephemeral and involve tacit knowledge [75], it did not make sense to simply conduct qualitative fieldwork in contexts where they occur. Instead, I decided to use Salud! as a type of technological probe (c.f. “technology probe” [14,49]) to assist in the research. Using Salud! would provide me with a temporal record of activity, and a novel, shared artifact that could facilitate both individuals and facilitators in articulating their *in situ* practices. It made sense to use Salud! specifically, instead of a different personal informatics tool because Salud! is flexible and can be configured to allow users to self-track a wide variety of data. Other personal informatics tools available at the time of these deployments were limited to specific types and representations of data. Additionally, Salud! offered a native interface for sharing end-user accounts with a facilitator. Finally, using Salud! in real-world contexts would allow me to informally evaluate its usability and utility (and address any serious issues), prior to integrating a goal management system.

Salud! was designed as a flexible personal health informatics application, and thus afforded use in diverse real-world domains. To obtain a broad sampling of practices, I expected to investigate how Salud! would be used in both a highly-structured, facilitator-dominated setting, such as a clinical environment, and a less-structured environment with greater power distribution between facilitators and their clients. The research objectives for the proposed deployments were:

1. Uncover and catalog behavior change and goal management strategies already in use in different health-related contexts.
2. Establish a conceptual foundation of goal management processes, which could be used to implement a goal management system in personal informatics applications.
3. Understand how a personal informatics tool like Salud! would affect communication patterns and other aspects of the relationship between individuals and their facilitators.

Selecting domains for such deployments was a challenge, and required several compromises between research goals and practical limitations. Originally, I had intended to deploy Salud! in a clinical setting, as well as in a less structured, wellness-focused setting. I met with several research directors at area clinics and hospitals: A Nursing Research Director[4] at Children's Healthcare of Atlanta (CHOA) was interested in using Salud! for longitudinal tracking of teenaged oncology patients; the Chief of Quality, Informatics, and Information Technology at a Piedmont Hospital-affiliated outpatient clinic attempted to get Salud! adopted by nurse practitioners at the institute as a home-monitoring system; I had several other conversations with nursing directors, research directors, and other practicing administrators at regional hospitals and clinics. Unfortunately, none of these connections led to a research proposal. I understood there to be three main reasons for why I could not get Salud! adopted in a clinical setting: (1) major, existing investments in outpatient monitoring and health tracking systems; (2) staff shortages; and (3) the pace and policy of technology research in clinical settings.

Hospitals and health systems that had made major investments in outpatient monitoring and self-tracking systems were hesitant to put in place a parallel system for similar

[4] Names and titles purposefully left vague to preserve contacts' anonymity.

tasks. The given reason was that the staff was already trained in the use of the existing system, and using a second system would make their lives complicated—an understandable and fully valid reason. A secondary, implicit reason seemed to be that administrative directors who had overseen the deployment of expensive infrastructure did not wish to undermine the evaluation of the value of the investment by having a secondary, free system—regardless of its comparative purpose or feature set. Staff shortage was another reason, cited by practitioners. At one regional heart outpatient clinic where I was introduced to the director of nursing, I was flatly told that staff were already working overtime and she would not allow anything that may siphon their time away to ambiguous ends. Finally, at organizations where there was interest from both administrators and practitioners (such as the oncology department at CHOA), the problem was a lack of clear policy for how to institute and administer an intervention like Salud! The timelines at which the organization moved—quarters and years—were substantially different from the timeline imposed by a Ph.D. dissertation—weeks and months.

Though frustrating, I believe that each of these challenges can be overcome by more informed planning, as well as by establishing ongoing research relationships between Georgia Tech and clinical organizations. Other members of my research lab who have since gone on to conduct HCI research in clinical settings (including at CHOA), have correctly started by building a relationship with the administrators and staff at least a semester prior to the expected start of the research. Systems that less obviously compete with existing solutions (e.g. games), as well as systems that require less attention from extremely busy staff—nurse practitioners, physicians, medical specialists, etc.—may also prove to be easier to deploy in clinical settings.

Deployment Overviews

In light of these developments, I sought alternative domains where I could deploy Salud! in real-world settings that matched my research objectives. I reached out to local gyms, fitness instructors and personal trainers, nutritionists, and other health and wellness professionals who work with groups of clients. To them, I offered Salud! as a self-tracking tool and light-weight communication system. The most fruitful of these efforts were meetings with fitness directors and personal trainers from various programs associated with Georgia Tech's Campus Recreation Center (CRC). The environment at the CRC provided three key important aspects of a successful real-world deployment of a research system: (1) supportive administrative staff, who has previous experience collaborating with university researchers, (2) facilitators who were interested in technological solutions to support their work with clients, and (3) clients who were willing to participate in a longitudinal research study. Over the course of two years, I was able to deploy the Salud! system in five different contexts at the CRC: the GIT FIT personal training program (described in this chapter), the 2011 GT Biggest Loser competition (described in this chapter), a large-scale pedometer-based fitness intervention (described in Chapter 6), an employee-wellness program piloted by GT Intramural Sports (outside the scope of this dissertation), and the 2012 GT Biggest Loser competition (outside the scope of this dissertation).

In this chapter, I will describe the methodology and findings of the two qualitative field deployments of Salud! at the CRC. The first of these, conducted in the fall of 2010, involved the GIT FIT personal training program. In this deployment, I queried twelve personal training clients and four personal trainers about their experiences and goal management strategies with regard to their training. Of these participants, two personal trainers and five of their clients went on to use Salud! over the course of several months as part of a longitudinal research study. The second deployment occurred in the spring of 2011, as part of the GT Biggest Loser competition. Salud! was integrated into the competition as a self-tracking tool, communication system between contestants and trainers, and as a score-keeping system. In total, seventeen contestants, four personal trainers, and one score-keeper used the system over the course of twelve weeks.

These two deployments allowed me to satisfy the requirement to analyze a fitness goal management context with a wider breadth of goals and goal realization strategies (GIT FIT personal training), as well as one with a more focused set of goals and a structured, pre-determined set of goal realization strategies (GT Biggest Loser competition). The GIT FIT deployment provided me access to end-users who had materially different personal health/wellness goals, and materially different approaches and motivations for achieving them (as will be described later). Conversely, the GT Biggest Loser competition allowed me to evaluate Salud! in a highly structured, high-stakes environment, more similar to that found in a clinical setting. The Biggest Loser participants had a singular, quantitative goal (lose the highest percentage of body mass), common strategies to reach the goal, and short-term, high-stakes rewards for reaching the goal (winning prizes). Though the profile of the GT Biggest Loser goals was definitely not the same as those in a clinical environment, they are closer to that domain than the diverse, open-ended goals of personal training clients.

Deployment Objectives

Taking into account the specifics of the deployment contexts, I narrowed the scope of the research objectives, and restated them as follows:

1. Use the Salud! application as a type of technological probe (c.f. "technology probe" [14,49]) to expose and uncover goal management strategies already in use by personal trainers and their clients, in different contexts.
2. Establish a conceptual foundation of the goal management processes, which can be used to implement goal management strategies and features into interactive applications (see Chapter 5).
3. Understand how using Salud! would affect the communication patterns of personal trainers and their clients, and what effect this would have on self-tracking, goal management, and behavior change practices/outcomes.

The first objective is concerned with investigating existing practices of personal trainers and their clients as they set and evaluate goals. Introducing Salud! into participants' fitness routines allowed me to engage them in articulating the details, assumptions, and tacit understandings of their practices and attitudes, as they integrated this new artifact into their routine.

The second objective is a precursor to the development of a generalized, goal management interaction that can be encoded into interactive applications. By examining how personal trainers and their clients conceptualize, set, and evaluate a variety of fitness/wellness goals, I go on to demonstrate how such an interaction can be modeled and embedded into an interactive application. The dual contexts provided by the GIT FIT and GT Biggest Loser deployments provided me with a variety of goals to examine: both quantitative, short-term goals akin to Action Plans, and informal, open-ended goals common in most peoples' lives.

The final objective is concerned with the novel communication channel offered by the Salud! application itself. Account data is visible to both end-users and their facilitators, and this allows the data itself to become a communication channel between client and trainer between workout sessions, as well as a shared resource that can spur conversation during workout sessions. The third research objective aims to understand how the introduction of Salud! into the trainer/client relationship changes its dynamics.

Deployment Descriptions and Methodology

In this section of the chapter, I present a detailed overview of the two field deployments at GIT FIT and GT Biggest Loser. The details provided in this section include subsections on deployment overview, participants, data collection methodology, and overview of the data that was collected. Following sections will describe the research instruments and data analysis methodology, in detail.

G.I.T. FIT Deployment

Deployment Overview

The G.I.T. FIT program is a personal training program available to Georgia Tech students, faculty, and staff. Individuals purchase sets of hour-long, one-on-one personal training sessions with GIT FIT trainers. Individuals usually purchase ten sessions at a time, and use them at a rate of one to three sessions per week. Individuals are assigned an ACE-certified personal trainer[5], who is usually a Georgia Tech student or recent alum. The assigned trainer works with the individual for the entirety of their sessions. If the individual purchases more training sessions, an effort is made to keep the same trainer (unless either the individual or the trainer asks for a transfer). Many trainers and clients

[5] http://www.acefitness.org/

work together for many months, or even years, with the relationship ending only when either the trainer or the client graduates.

Personal trainers in the GIT FIT program work with clients who have a variety of health and wellness goals. These will be discussed in detail further in this section. However, common client-initiated goals include: lose weight, build muscle, recover from injury or surgery, train for an athletic event (e.g. 5k or marathon), learn or improve exercise strategies, or simply be held accountable to exercise on a regular basis.

Methodology

The GIT FIT deployment was designed to be a longitudinal study involving personal trainers and their clients, lasting approximately six weeks. Each participating trainer was asked to recruit her or his clients to participate. The client received a Salud! account, with her or his trainer receiving facilitator access. I interviewed each client and each trainer weekly, with the semi-structured interviews focusing on their fitness regimen, their communication patterns, and discussion of the clients' goals.

During the introductory interview, I introduced trainers and clients to the features of Salud! and walked them through using the system. I then discussed the clients' short-term, medium-term, and long-term health/fitness goals—what they were expecting to accomplish via personal training, as well as their ultimate fitness goals. Based on these discussions, I worked first with the client, and then the trainer, to co-create Logbooks that matched their fitness objectives. Trainers and I both instructed clients to use their Salud! account to log their fitness regimen, track the progress of their goals, or for any other purpose that suited their needs or interests. During subsequent interviews, clients and trainers had opportunities to modify their Logbooks and/or create new ones. Both clients and users were also able to edit Logbooks on their own, and many did (more on this in Findings).

In addition to weekly interviews, clients completed introductory and concluding surveys, described further. Participants were compensated for their time spent in interviews: clients at a rate of $10/hour and trainers at a rate of $20/hour. This was judged to be fair by the Institutional Review Board because clients had more to gain from using Salud!

Participants

I recruited four personal trainers from the Fall 2010 GIT FIT program through introductions arranged by the Campus Recreation Center's assistant director for Healthy Lifestyle Programs. Three of the trainers were Georgia Tech undergraduates, and one trainer was a Master's candidate in Sports Administration at a different Atlanta-area university that is also part of the University System of Georgia. I recruited an additional trainer who was not affiliated with Georgia Tech, but was referred by one of the other trainers. She was also an ACE-certified trainer who worked at a local gym. See Table 4.1 for a summary of trainer information.

Of the five trainers I recruited, only two (T1 and T2) were able to recruit clients to participate in the study. These two trainers recruited two and three clients each, respectively. These five clients were a diverse group (see Table 4.2). Four of the clients were male and one was female. Their ages ranged from 21 to 51, and experience with personal training ranged from complete beginner to several years. The clients included an undergraduate student, two young professionals in non-technical fields, a university staff researcher, and an IT manager. These five clients also represented a diverse set of personal fitness goals, including: losing weight, building muscle mass, recovering from surgery, and maintaining current level of fitness.

All trainers and clients were recruited and completed their introductory sessions by the first week of September 2010. All clients participated in six interviews, with the last interviews occurring in the first week of November. Due to availability, trainers participated in four interviews (T1) and five interviews (T2), respectively.

GT Biggest Loser Deployment

Deployment Overview

GT Biggest Loser is a competitive weight-loss program open to faculty, staff, and students at Georgia Tech (see Figure 4.1). It is modeled on the U.S. version of the reality TV game show, *The Biggest Loser*. In the university-wide competition, as in the TV show, contestants who are overweight participate in an intensive weight-loss program.

Performance is based on overall percent of body mass lost during the twelve-week contest, as well as points earned for different fitness and weight-loss activities. There are individual and team-wide prizes for highest percent of body mass lost as well as most points earned. A large, public scoreboard is updated weekly at the Campus Recreation Center (CRC) as well as on the CRC website.

To qualify as a contestant, individuals must be beginner exercisers and be at least twenty pounds over their ideal weight. Each contestant pays a participation fee, which entitles her or him to participate in group workout sessions, unlimited access to the gym, as well as unlimited access to any group fitness classes, and attendance to several fitness-related seminars held through the contest. Individuals interested in becoming contestants submit an application prior to the start of the competition. The applications are reviewed by CRC staff to ensure that applicants meet the qualifications and have a physician's permission to participate in the program.

A personal trainer is assigned to each GT Biggest Loser team. The team's trainer leads exercise sessions, provides fitness advice, and monitors participants' progress. Personal trainers and their teams meet at least twice a week for hour-long workout sessions. Contestants are also provided with a pass that allows them to attend any group fitness class offered at the Campus Recreation Center at Georgia Tech, for free. All participants are asked to keep a food log and exercise log, which are reviewed weekly by their team's trainer. Contestants earn points for attending workout sessions, group fitness classes, and educational seminars. Additional points can be earned by through special "last chance" workout sessions, by completing a "Bingo card" of various group fitness classes, and through several other competition mechanisms. An official weighed-in of all contestants occurs once a week.

Prior to 2011, all GT Biggest Loser recordkeeping was performed using pen-and-paper. Participants filed nutrition logs, fitness logs, and other data on physical forms. If participants chose to use nutrition-tracking websites such as FitDay[6] or SparkPeople[7] (a short list was provided as part of the introductory materials), they needed to print them out weekly for competition purposes. Both trainers and CRC administrators felt that the manual data entry and recordkeeping was inefficient and error-prone. It was difficult to keep track of the various attendance lists, nutrition logs, point totals, and official weigh-ins. This resulted in extra work for everyone involved, as well as delays in updating competition results and in providing contestants with feedback with regard to their progress, performance, and activities.

Competition administrators as well as personal trainers involved were interested in using Salud! as an integral part of the 2011 competition. Both groups hoped that using the system would mitigate the problems with pen-and-paper recordkeeping, as well as provided benefits for contestants. Before the start of the competition, I met several times with the trainers who would be involved, the two CRC directors who organized the competition, and an intern who would work to ensure accurate recordkeeping and assignment of points. We came to a consensus about how Salud! would be introduced, the structure of each participants' Salud! account, and the responsibilities of the trainers, competitors, and assistant with regard to data entry and review.

Everyone was also informed of the requirements of the research study, and briefed on how data would be collected, analyzed, and stored to balance the public nature of the competition with the privacy requirements of an IRB-approved study. One of the competition directors was added to the study's IRB protocol.

Custom Salud! Features

I developed several custom Salud! features specifically for the GT Biggest Loser deployment. These features, as well as their design rationale, are listed below. Most of the features made direct use of the Salud! API and helped demonstrate how the service

[6] http://www.fitday.com
[7] http://www.sparkpeople.com

stack could be extended to provide tailored functionality for specific research and logistical needs.

The functionality of locked Logbooks was added so that participants could not edit their points and official weigh-in Logbooks. Locked Logbooks can be viewed by both end-users and facilitators, but only be edited by a facilitator (personal trainer, in the case of GT Biggest Loser).

To assist the process of assigning points (which were added into a locked Logbook), I built out basic functionality to support multiple facilitators for an account. Each GT Biggest Loser contestant had two facilitator accounts: her or his team's personal trainer, and a competition-wide account used by the intern responsible for points entry and validation. This made it easier to review each contestant's points and entries. It also made it possible for any trainer to enter a weigh-in for a contestant from another team, if necessary (but without the need for all contestants' accounts to be visible from every trainer's facilitator account).

Each trainer had between four and five contestants on her or his team, and every contestant had at least five Logbooks in which they could track personal data relevant to the trainer. All of the trainers wanted a way to be able to see updates in their teams' accounts, without needing to manually look at every Logbook in every account. A simple remedy to this was to create a Salud! service that sent facilitators a daily summary of their clients' Logbook activity. The summary included information about whether Logbooks were created, edited, or deleted, as well as which Logbooks had new data entries. However, to encourage facilitators to log in to the application, I purposefully left out the details of the data entries; to view the data, the facilitator had to access her Salud! account using either the online application or the mobile application.

Finally, I implemented an experimental feature that allowed clients and facilitators to exchange message inside the Salud! application. This was implemented via a special "Chat" Logbook, which acted as an asynchronous repository of messages. Creating a new entry was akin to sending a chat message. The other individuals (facilitator or client) would receive an email alert notifying them of the new message with a direct link to open the Logbook. Messages (i.e. Logbook entries) were also color-coded based on who sent the message and whether it was seen by the other participant (see Figure 4.2).

Methodology

Each GT Biggest Loser contestant created a Salud! account during the introductory session. During the session I also gave a live tutorial on the features of Salud!: tracking and reviewing personal health and fitness data (using Logbooks and entries), setting reminders for data entry, using mobile services to enter and review data, and sending messages to a trainer. The lead personal trainer then described how points and weigh-ins would be tracked via the application. He also discussed the benefits of tracking other data Salud!.

Contestants were given the option to use the Nutrition Log, or a third-party website for tracking their eating habits. There was no penalty for using a third-party website, but required a contestant to deliver a copy of the weekly log to her trainer via printed copy or email. This step was not required if using the Nutrition Log Logbook, as both the trainer and the intern received notifications when it was updated. In addition to the Nutrtion Log, participants were provided with the following Starter Logbooks:

- **Cardio Exercise**: Three columns: Type (text), Duration (numeric), and Notes (text).
- **Strength Training**: Three columns: Description (text), Duration (numeric), and Notes (text).
- **Nutrition Log**: Three columns: Photo (picture), Calories (numeric), Description (text), and Meal (text).
- **Sleep**: Two columns: Length (numeric) and Notes (text).

Each participant was asked to participate in two interviews during the course of the program. The first set of participant interviews happened around the mid-point of the competition, and the final set during the final week of the competition, as well as the following week. Similarly to the GIT FIT participant interviews, the interviews with GT Biggest Loser contestants focused on their fitness goals (short-term, medium-term, and long-term), how they expected their participation in the program to help them realize their goals, and their interactions with their team's personal trainer.

In addition to interviews, contestants completed introductory and concluding surveys, described in the Research Instruments subsection. I was also provided with copies of contestants' goal articulation forms (which each participant filled out during the introductory session), as well as self-evaluation forms from the final session. All participants were offered compensation for their time spent in interviews: contestants at a rate of $10/hour and trainers at a rate of $20/hour.

Participants

The 2011 GT Biggest Loser competition began with nineteen contestants, who were assigned to four different teams, each with a lead personal trainer (see Table 4.4). Contestants' ages ranged from 20 to 56, with an approximately equal distribution between undergraduate students and faculty/staff. Fourteen contestants completed the competition, while five dropped out of the competition within the first few weeks, either without cause or citing overloaded schedules.

During the first few weeks of the competition, I individually invited contestants to participate in an interview about their experience. Of the fourteen contestants who were still in the program around the sixth week, eight participated in an initial interview. Several weeks before the end of the competition, I again invited every contestant (who had not explicitly opted out) for an interview. In the second round of interviews, I was able to secure participation from five contestants, all of whom had also participated in the initial round.

I similarly invited every team's personal trainer to participate in both an initial and final set of interviews. Three trainers participated in the first round, and two of those then participated in the second round. The trainer who was not interviewed did not opt out of interviews, but was unable to attend any of the timeslots he and I scheduled over the course of the competition.

Of the participants who finished the competition, all lost weight. The amount lost ranged from 2% of body mass to 18% of body mass for the winner (C12). The total number of points earned (i.e. level of engagement with the program) similarly varied, from 34 total points to 211 for the points winner, who was the same as the weight-loss winner.

Both weight-loss and earning of points showed some consistency across the members of a team. For example, on the winning weight-loss team (L3), each contestant lost at least 11% of body mass, while on team L1 each contestant lost less than 5% of body mass. Similarly, some teams took points seriously, with each team member earning at least 100 points, while other teams did not consistently participate in point-earning activities.

Research Instruments

I used a similar set of research instruments for both deployments. For this reason, they are described in a single section. The introductory and concluding surveys used in the GIT FIT deployment are attached as Appendix A. The introductory and concluding Biggest Loser surveys were very similar to the GIT FIT surveys. Where appropriate, questions were rephrased or omitted to make them consistent with the alternate context.

Surveys

I used introductory surveys to collect GIT FIT clients' and GT Biggest Loser contestants' demographic information and fitness background. The surveys also asked participants to list fitness and wellness goals they were looking to achieve. A purposefully extensive pre-populated list was provided, with additional room for write-in answers, to serve as a prompting device for interviews.

Every survey included two validated Generalized Self-Efficacy (GSE) scales: Schwarzer's GSE scale [78] and Sherer's GSE scale [81]. I included both scales as it was not clear from the research literature which scale was more appropriate for the present context. As both scales are quite short, I decided to include both of them. As there is no universal "high" or "low" GSE cut-off, both scales are intended to separate populations into relatively high and relatively low subpopulations [79].

The concluding surveys asked participants to generally rate the usefulness and interestingness of the data they had collected in their Salud! account. The concluding survey for GIT FIT participants also asked them to reflect on each of the goals they selected in the introductory survey. In addition to quantifying their experience with the program and with Salud!, this strategy prompted participants to begin thinking about and reflecting on their goals before the beginning of the concluding interview.

Interviews

The semi-structured interview scripts were also consistent between the GIT FIT and GT Biggest Loser studies. There were separate scripts for trainers and clients/contestants.

Introductory interviews with clients/contestants focused on their background with personal fitness, their short-term and long-term fitness/wellness goals, and their expectations for the program in which they had enrolled (GIT FIT or GT Biggest Loser). I then asked the participant to describe and discuss any previous experience with self-tracking for health, wellness, or fitness purposes. Finally, I went over the features of Salud! with the interviewee, and answered their questions about the system. In the GIT FIT deployment, the introductory interview was also a time to begin brainstorming Logbooks the participant may want to create (or have created for her or him).

Introductory interviews with trainers began with a discussion of their background in personal training. The majority of the interview, however, was spent discussing their strategies for working with clients, and specifically for helping clients meet their fitness goals. I asked trainers to provide specific examples of goals their current and past clients articulated, and how they had gone about assisting those clients. In the final portion of the interview, we discussed the trainer's attitudes and practices with respect to tracking client progress, as well as client self-tracking.

The emphasis in concluding interviews with clients/contestants was a detailed walk-through of their Salud! account. During the walk-through, I asked participants to describe their experience with each Logbook in their account, and the data in each Logbook, in detail. I questioned the value and "interestingness" of the Logbook, why the participant was interested (or not interested) in that kind of data, alternatives to the data which may be more useful and/or more interesting, and whether the Logbook represented movement toward a goal. For those Logbooks that did represent goals or potential goals, I questioned participants about how they framed the goal and how they evaluated it in their fitness practice. An important final component to the concluding interview was a discussion of how Salud! did (or did not) affect the client's relationship and communication patterns with her trainer. The concluding interviews with trainers followed a similar script, but we would go through each of the trainer's clients or team members one by one (and with equal emphasis on the trainer's own perspective on the client's or team member's data and communication practices).

During the GIT FIT deployment, I had additional follow-up interviews with both clients and trainers between the introductory and concluding interviews. During these follow up interviews, I discussed the participants' use of their Salud! account and the Logbooks in it. Frequently, we brainstormed alternative Logbook representations for the data the client was tracking. Whenever possible, I would ask the client to try an alternative Logbook representation, or an alternative way of entering data. Because clients had diverse goals, this allowed me to evaluate the effectiveness of different goal representations. I also questioned both clients and trainers about their ongoing fitness practices, and how their relationship was evolving (or not) due to use of Salud!

<u>Other Collected Data</u>

Several other sources of data completed the overall dataset available to me:

- Post-interview notes and summaries.
- Data that participants entered into Logbooks.
- Metadata captured by the Salud! backend, such as a data point's entry method.
- Feedback sent via a form embedded in the Salud! application.
- Additional surveys provided by GT Biggest Loser administrators and completed by the contestants (self-evaluations, contest evaluations).
- Nutrition logs of contestants who used a third-party nutrition tracking website.
- Paper exercise logs kept by trainers for their GIT FIT clients.
- Photographs of items or equipment used by study participants in relation to their fitness practice, use of Salud!, or other relevant context.

BIGGEST LOSER

Returning Spring 2012

Are you the CRC's Biggest Loser? If you are a GT employee or student who is a beginner exerciser with 20 or more pounds to lose, the answer may be "Yes!" See below for all program requirements and benefits.

All questions can be directed to Faith Doldo at faith.doldo@crc.gatech.edu or 404-385-1651.

Participation

Requirements

- Must be a Georgia Institute of Technology employee or student (CRC members and non-members welcome)
- A beginner exerciser
- Have 20 or more pounds to lose
- Able to commit eight hours a week
- Provide proof of having a physical exam in the last year and have a Doctor's note for participation
- Participate in three group workouts a week
- Keep an activity log and food journal through the program
- Have written acknowledgment from your direct supervisor indicating that he/she knows that you are applying for this program and supports you in your journey (faculty/staff only)
- Willing to release results for publicity purposes

Upon acceptance into the Biggest Loser program, participants will receive:

- Polar BodyAge Assessment
- Personal Training
- Motivational Coaching
- Nutrition Education
- Group Fitness Membership

Workouts will consist of group workouts and team workouts with the team personal trainer. A nutrition and workout log will be kept by the participants. Weigh-ins will be bi-weekly.

Click here to download the Application!

Click here to download the Medical Release Form

Figure 4.1. CRC recruitment webpage for GT Biggest Loser. This document provides a succinct overview of the program's participation requirements, procedure, and expected outcomes. (© 2012 Georgia Institute of Technology. Reproduced with permission.)

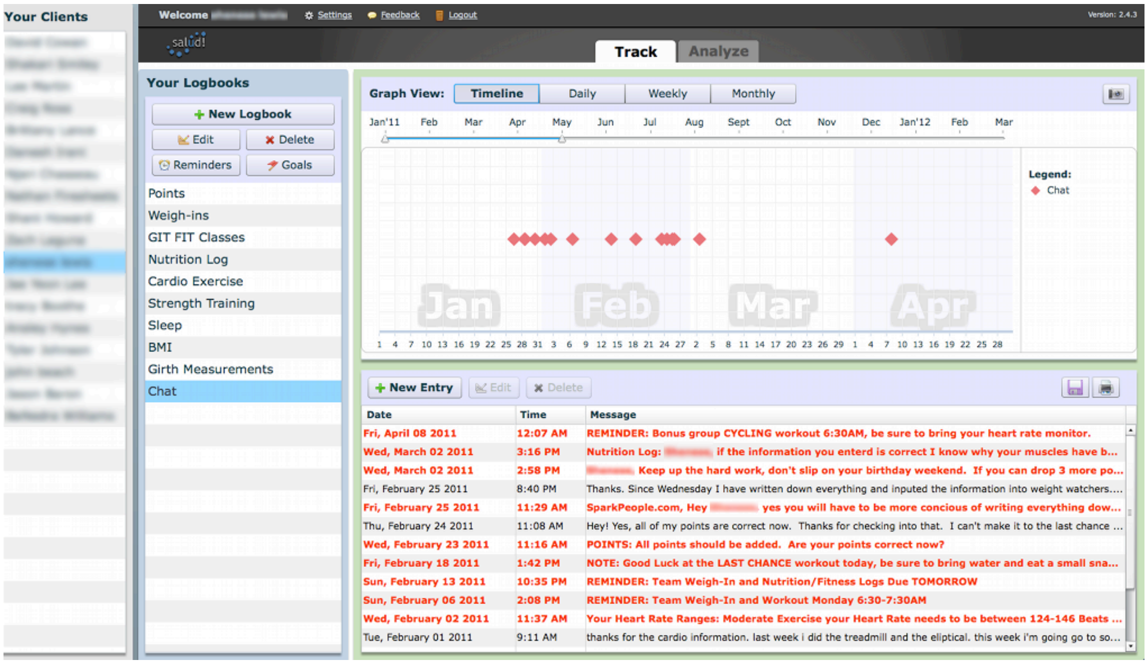

Figure 4.2. GT Biggest Loser facilitator interface, with a Chat Logbook is selected. The red messages are from the facilitator and the black messages are from the contestant. Names blurred to protect participants' identities.

Table 4.1**. G.I.T. FIT study participants: personal trainers.**

Trainer	Age	Gender	Affiliation	Clients Recruited	Total Interviews
T1	21	F	GT Undergrad	3	4
T2	23	M	GT Undergrad	2	5
T3	26	F	Non-GT Grad	0	1
T4	22	F	GT Undergrad	0	0
T5	28	F	Professional	0	1

Table 4.2. G.I.T. FIT study participants: clients.

Participant	Trainer	Age	Gender	Occupation	Main Goal(s)
P1	T1	37	M	IT Services	Rehabilitate after surgery
P2	T1	51	F	Researcher	Keep active
P3	T1	27	F	Marketing	Lose weight
P4	T2	27	M	Financial Services	Build muscle
P5	T2	21	M	Student	Improve sports performance

Table 4.3. GT Biggest Loser participants: personal trainers.

Team	Age	Gender	Affiliation	Team Size	Interviews
L1	21	F	GT Undergrad	4	2
L2	23	M	GT Alum	5	0
L3‡	23	M	GT Undergrad	5	2
L4	22	F	Non-GT Grad	5	1

‡ Team weight-loss winner and team points winner.

Table 4.4. GT Biggest Loser participants: contestants.

Contestant	Team	Age	Gender	% Body Mass Lost	Total Points	Interviews
C1	L1	--	--	--	--	0
C2	L1	33	F	3	124	2
C3	L1	--	--	4	109	0
C4	L1	20	F	2	74	1
C5	L2	32	F	4	81	2
C6	L2	--	--	--	--	0
C7	L2	21	M	8	76	2
C8	L2	--	--	--	--	0
C9	L2	36	F	11	34	1
C10	L3	--	--	--	--	0
C11	L3	--	--	11	142	0
C12‡	L3	--	--	18	211	0
C13	L3	56	M	14	166	1
C14	L3	--	--	11	149	0
C15	L4	34	F	12	193	2
C16	L4	22	F	4	87	2
C17	L4	--	--	--	--	0
C18	L4	--	--	4	127	0
C19	L4	--	--	8	132	0

‡ Individual weight-loss winner and individual points winner.
Grayed-out contestants did not finish the competition.
Contestants who opted out of interviews do not have demographic information listed.

Research Findings

Between the two deployments described in this chapter, I obtained 59 recorded interviews, along with survey data and other relevant information from 21 individuals. All of the interviews were transcribed. In this section, I first briefly describe the qualitative analysis method for distilling this data into findings relevant to the three research objectives listed earlier in this chapter. I then present the findings, grouped by research themes that emerged from the data.

The findings related to participants' actual goal management practices are engaged in Chapter 5, where they assist me in developing a generalized model of goal management. The findings related to communication patterns between personal trainers and their clients or team members, as well as the findings related to attitudes and uses of a personal informatics application, are discussed in depth at the end of the chapter.

Data Analysis Methodology

I analyzed the data from the two deployments using a general inductive approach for qualitative data analysis [85]. I additionally looked to [80] for guidance in the focused analysis of interview data.

Key Emergent Themes

I used the research objectives discussed earlier in this chapter as a lens to extract key categories/themes from a close reading of the interview data. These four themes were:

1. Communication (between trainer and client or team member).
2. Accountability (of the client or team member with respect to their goal).
3. Goal articulation.
4. Attitude toward self-tracking data.

A further recurring theme was discussion of Salud! features (both existing and proposed). Most of the data related to this theme is not directly related to the high-level research objectives that motivate this chapter, and so it is not taken up immediately. However, I provide a summary section after the main findings section, highlighting participants' main comments with respect to Salud!'s feature set.

Participant Profiles

Seidman recommends using participant profiles to highlight the unique experiences of interview participants and to maintain accuracy in qualitative research outcomes [80]. Though the interviews from the two deployments presented here were more focused in their content than the kind discussed by Seidman, I found it useful to separate the key emergent themes across four different participant profiles. These four profiles emerge in a straightforward way from the quantitative and demographic data I collected in surveys and use logs. However, the holistic experience, attitude, and outcomes of each of the GIT FIT clients and GT Biggest Loser contestants who participated in the studies fits well into one of these profiles. Below, I briefly describe the four profiles. They are filled in more thoroughly throughout the Findings subsection:

1. **Enthusiastic user**: This participant used Salud! at least several times a week, on average, over the duration of the study. The participant agreed “somewhat” or “to a great extent” with the statements that the data in her Salud! account was interesting, useful, and helped her uncover interesting or useful patterns in her activities. This participant created her own Logbooks, and/or appropriated Starter Logboks by entering data in a unique, personal way (as opposed to the way suggested by the Logbook name and column descriptions).
2. **Casual user**: This participant used Salud! once or twice a week, on average. Her use was also likely to be bursty: use it several times one week, and then not at all for two or three weeks. This participant was not likely to create a custom or personal Logbook, and entered data in the way consistent with a Logbook’s name and column prompts/descriptions. The casual user was likely to say that she made some progress on at least some of her goals, but generally disagreed with the statement “using Salud! facilitated progress toward this goal.”
3. **Progressive non-user**: The progressive non-user only logged in to Salud! before a scheduled interview, or once every few weeks to enter data for GT Biggest Loser points. She is likely to have fewer than a dozen data entries in her account (except for GT Biggest Loser points-related entries). This participant reported significant progress toward her goals at the culmination of the deployment.

4. **Static non-user:** Like the progressive non-user, the static non-user rarely logged in to Salud! and is not likely to have more than a dozen data entries in her account. However, this participant reported little or no significant progress toward her goals.

Because only a handful of trainers participated in interviews, and of those only three worked with the clients or team members, I did not break out trainers into separate participant profiles. Instead, I provide the trainers' perspective when it either supports or contradicts another finding in an interesting way.

An important limitation of these findings, as well as of the participant profiles overall, is that GT Biggest Loser interviewees self-selected to participate in the interviews. Overall, only about half of GT Biggest Loser participants agreed to be interviewed, and I did not feel that data saturation was attained with regard to participants' experiences. Notably, there is only one participant across both deployments who fits the progressive non-user profile. However, the overall GT Biggest Loser winner (C12), who opted out of the interviews and surveys, would have likely also been categorized into this profile, potentially fleshing out its boundary. It is not clear if the experiences of other GT Biggest Loser participants would have created a need for other profiles, additionally fleshed out the existing profiles, or had no significant impact on the analysis.

Findings

In this section, I present the results of the qualitative data analysis performed on the data collected from the deployments of Salud! at GIT FIT and GT Biggest Loser. The findings are structured to mirror the key research themes and participant profiles described in the previous section. For each participant profile, I present the significant findings with respect to each key theme.

<u>Enthusiastic User, Attitude toward Self-tracking</u>

Enthusiastic users discussed self-tracking in detailed, quantitative terms. These participants regularly entered data into several Salud! Logbooks in their account, and often created personal Logbooks to track relevant, personal variables. All of the participants under this profile also updated their Nutrition Log in Salud!, though one additionally kept a primary log on a third-party nutrition-tracking website.

Participants represented by this profile were reflective about their data entry habits, and provided details about how they had appropriated Salud!'s default Nutrition Log to suit their particular tracking method. For example, C7 noted that he used a tilde (~) as a symbol for "approximately" when entering calorie data for home-cooked meals that he did not prepare himself. This strategy is reflective in that it embeds an additional level of precision into the calorie data. Both C7 and his team's trainer could see which entries needed to be considered separately when evaluating daily calorie intake.

> I'm actually really conscious now about specifically the calories, carbs, protein, and fiber and I've found it really easy to control my first two meals in that I make them personally….[But] my parents usually cook dinner…I usually put the little squiggly guy [tilde] when I eat dinner because it's never as controlled as when I make a sandwich. *–C7*

Enthusiastic users also integrated the data entry process into their daily routine. They did not report batching several days of data to enter. Instead, they either entered their data on the same day (sometimes immediately after the relevant event), or they did not enter the data at all. P4 noted several regular times during his day when he would quickly log in to Salud! to enter meal data. He also had a nightly Salud! email reminder, which was his prompt to make any data entries he had not yet made that day.

> For food, I do it [make a Logbook entry] the moment I eat something, because then I keep track of the time, because I'm looking at the spacing between the food, not just what I ate. But for things like workout, I do as I remember, but then I have just one reminder set for the food thing. That comes every night, so by then I make sure that I have made all the entries. So usually I do the entries as when I remember, but by the end of the day I make sure that I have entered data for everything for that particular day. *–P4*

In summary, participants who adhered to the "enthusiastic user" profile were comfortable entering detailed data into their Salud! account, and did so with reflection on their practice. They were able to integrate data entry tightly into their daily routine.

<u>Enthusiastic User, Goal Articulation</u>

Enthusiastic users from GIT FIT already came into the deployments with specific, actionable goals in mind. For example, P4, who was in the program to build his muscles, frequently discussed specific dietary goals that he was trying to adhere for best muscle-building performance. For example, he tried to eat three, regularly spaced meals each day. The notion of a goal to *regularly space* an activity implies not simply a quantity or count (e.g. number of meals, sum of calories, etc.) but also an optimal temporal pattern to which activity can be adhered (and deviation from which can be measured quantitatively). He reviewed his performance with regard to this goal by looking at the "gap between each meal;" indeed, he even requested that the dots which represent discrete entries on a timeline be reduced in size so that it was easier to compare gaps.

P4 also had a quantitative protein-intake goal. He created a Salud! Logbook to track his daily protein, but found that a recent life change (starting a new job) made this more difficult to do accurately. Nonetheless, he still kept in mind the specific number of grams the optimal performance.

> I need to have at least 75 grams of protein per day. So the intention with which I started this protein logbook was to monitor if I was having enough protein. But then I found it hard to come up with the protein amount in the food I was having. Earlier when I was in college eating in the dining hall they used to have it written for each and every meal so I could come back and calculate by the end of the day if I had enough protein. But once I started working on my own or eating outside it's been hard to monitor. So this one finally ended up being – all the dots here are the days that I have protein. So they correspond to the days when I did weight training. So in the end it's just a reference to me to see how many days have I done a workout.
>
> *–P4*

Those enthusiastic users in the GT Biggest Loser program developed such goals during the course of the contest, as they learned about weight control. However, some felt that the program did not provide enough quantitative guidelines. C15, for example, tried to look for this information, so she could log it, on her own:

> For me, I had to just eat 1,200 to 1,300 calories, and that's what I focused on. So the nutrition log helped me put that all in perspective and be accountable for what I ate so that I know exactly by the end of the day how many calories I've had that day. [But] there're other sides to it. There's the fat. There's the protein…I had to

> search for that on my own as far as how much–based on the calories–how much fat should I have? *–C15*

Of course, enthusiastic users (like all participants) also spoke about broad, general goals: becoming healthier, looking better, eating more healthfully, being stronger, etc. However, they introduced these goals early on and shifted to discussing their specific, short-term goals over the course of the interview (or interviews).

Thus, participants who were categorized into the enthusiastic category had (or wanted) goals of the type suggested by Action Plans—specific, short-term, and actionable—in addition to their broad goals. They were comfortable creating or using Salud! Logbooks that required numerical data entry, and used (or tried to use) these to track their goal progress.

<u>Enthusiastic User, Communication with Trainer</u>

The effects of Salud! on communication with the trainer, for all participants, varied significantly based on whether the trainer provided feedback on her or his Salud! use. Those enthusiastic users whose trainer reviewed their data in Salud!, or whose trainer did not provide *clear feedback* about whether she or he reviewed the participant's data in Salud!, treated data entered into the system as common ground for future interactions.

> I've used trainers before….and when you see them you spend five minutes at the beginning "Hey, how's your workout been going this week?" and "Have you been eating bad? Have you been drinking your water?" Sort of like a catch-up. But with this she was able to catch up with me without having to go through all that so that when I did train we were able to just jump into the training. And she was able to see what areas were lacking in my workouts by myself so that when we were together she could focus on those areas. *–P3*

Trainers also liked the ability to check up on clients' activities prior to a scheduled workout session. Even if the only time they checked a participant's account was right before meeting them (or their team), having recent data helped them quickly calibrate an appropriate workout.

> It definitely changes the context, so you have conversations instead of interrogation….So, it definitely creates a more encouraging conversation 'cause I

> can already see that they've done the work. I don't have to sit there and kind of be that bad guy that just interrogates 'em. *–L2 Trainer*

> [S]he's done her cardio workouts here and that's nice for me to see when she puts the type and how long she's done it. And she was doing physical therapy for her back…it's nice to see that since she went to physical therapy yesterday we probably don't have to focus as much on back strengthening exercises. *–T1*

The flip side of this communication channel, however, was that an enthusiastic user could also tell if their trainer was *not* reviewing Salud! data—if the trainer had promised to enter some data as well (e.g. a workout log), or create new Logbooks. In this case, because she logged in regularly, the enthusiastic user could tell the delay and frequency with which account changes happened (if at all).

<u>Casual User, Attitude toward Self-tracking</u>

Participants whom I classified under the casual user profile had substantially different experiences with self-tracking. Each of them discussed wanting to be better at the practice—both with regard to previous attempts, if any, as well as the current deployment. The consistent reason provided for why they did not enter data more regularly was being busy, or forgetting.

> I need to be a lot better about that, 'cause it's helpful….You come back to the office and you forget the things that happened while you were gone for the last hour and a half, and just get sidetracked with everything. Gotta do this, gotta do that. *–P1*

Casual users had a different understanding of "consistent use" than enthusiastic users. All went through periods where they did enter data into Salud! for several days or weeks at a time. However, a common practice among users in this category was to batch or delay entries. They would compile data over the course of several days (often just in their memory), and enter it in a single session.

> I have used SparkPeople before in the past….but not consistently. Now it's consistent, you know, like if I don't do it on the weekend then definitely Monday when I'm back in the office, I'll log everything that I did exercise-wise for the weekend. *–C2*

Casual User, Goal Articulation

Casual users in the GIT FIT program articulated general goals as well as more targeted goals. For example, P1 had several broad goals, such as losing weight and lowering cholesterol, as well as a primary, specific goal, which was to bench press the same weight he had been able to, before a recent surgery. P5 also had a specific goal, which was to improve his sports performance, and which was not interested in quantifying.

> I like to say that's my goal, is to improve my gymnastics performance. But also, you know, just to be more toned and better looking. *–P5*

A common type of specific goal among casual users who were GT Biggest Loser contestants was to run a 5K, 10K, or half-marathon.

> I mean, I know this is like a distant goal, but possibly like a half marathon as well. I think that'd be really – that will really show that, you know, I have improved my physical activity. *–C16*

However, the specific goals that casual users articulated throughout the course of interviews did not have all three components of an Action Plan: specificity, brevity, and actionability. Some participants, such as C16 and P1, spoke of specific goals, but they were "distant goals." Additionally, these goals were often unrelated to any significant portion of their activities—either with their trainer, or during daily life.

Casual User, Communication with Trainer

None of the participants under the casual user profile experienced Salud! as a differential method of communication with their trainer. It was common for some participants to report only intermittent logistical communication with their trainer: such as scheduling or coordination. Other participants treated their communication with the trainer holistically: they used emails, text messages, physical artifacts (e.g. nutrition log printouts), the Chat Logbook, and other media as called for by the situation or habits.

Progressive Non-user, Attitude toward Self-tracking and Goal Articulation

I classified only one participant across both deployments into the progressive non-user category. However, C13's experience was substantially different from the rest of the participants, with regard to his outcomes and use of Salud!, that I believe this classification is warranted.

C13 was a habitual self-tracker, and tracked a variety of variables—especially with regard to nutrition. He also articulated short-term, actionable goals, though they lacked quantitative specificity.

> I just have a little notebook…and I just keep up with it and handwrite it. It's not terribly well organized. I don't count calories, [but] I do serving sizes. And the types of food: I'm sensitive to calling it vegetables and fruits and fiber and water and making sure that I get enough servings of those each day….It makes [me] aware that I'm eating enough fruits and vegetables and fiber, or not enough. Or if I'm getting enough of the water each day. And, those are my goals: to fill up my system with water, fruits and vegetables, as opposed to, you know, chocolate and beer. *–C13*

All of C13's self-tracking was handwritten, and he used a designated notebook for his food log. He had tried nutrition-tracking websites, but was dissatisfied with the detail and structure of their requirements. In that regard, he was most enthusiastic about the Nutrition Log provided as one of Salud!'s Starter Logbooks for GT Biggest Loser contestants. However, he said he would not even think of using it until an iPhone version was available—it was just much easier to write something in a notebook.

> [The team's trainer] offered three or four of the nutrition websites to work with, but…it's just a lot of work to set 'em up to begin with…And life is just not as structured as these websites seem to think it is. So, you know, when I go eat lunch, it's whatever they have—mixed vegetables, or peas and, you know, meatloaf. And, with my whole thing, I just write down what it is. *–C13*

C13 was the second place weight-loss contestant, and so his practices were ultimately successful. He provides a very important counterpoint to a trend otherwise present in the data: that higher use of Salud! was correlated with higher likelihood of reporting satisfactory progress towards goals.

<u>Static Non-user, Attitude toward Self-tracking</u>

C5 represents an extreme position on self-tracking among participants classified into the static non-user category:

> I do not own a scale at home, I don't take measurements. I just base it on how my clothes feel, you know. Prior to this [Biggest Loser], I just based it on how my clothes feel and what have you, that's it. *–C5*

Throughout the entire deployment, C5 was not interested in self-tracking. Instead, she spoke about changing her habits and working toward "healthier lifestyle." C5 did not enter data into her Salud! account—for her it was a system where she could track her progress through the GT Biggest Loser program.

> Right now I'm using it [Salud!] for my points, and I go in and see, you know, the graph of the weight and if it's moved or not. That's about it. *–C5*

Most participants aligned with this profile did not take such a strong stance, but they did agree that self-tracking was not something they were doing at all in the present time. They may have tried it in the past or looked forward to making a habit of it in the future, but it was not a major concern for the duration of the deployments.

> I do go to Weight Watchers, and the number one way you lose weight is tracking….[But] I haven't been as good about that over the last few years as I should have. *–P2*

Static Non-user, Goal Articulation

At the start of the deployments, static non-users had very general goals.

> I'd like to be comfortable working out on my own….I also just wanna be healthier in general and reduce my risk of a lot of different things or possible diseases or problems later in life. *–C4*

However, the lack of specific goals persisted through the deployments. None of the static non-user participants articulated quantifiable goals or objective goals (e.g. running a 5K) during the concluding interview. P2 was conscious of her lack of quantifiable goals, and stated her contentment with that state, at least for the time being:

> You know, for me – there's nothing quantitative I'm trying to track per se. I'm just trying to do the right thing…So the fact that I did 30 minutes on this elliptical versus 30 minutes on the other elliptical – it's just a snapshot in time. They're not necessarily connected….*I have goals in my life, but not ones that I can track in Salud! right now. –P2*, emphasis added

Static Non-user, Communication with Trainer

Participants who were static non-users did not perceive Salud! as a communication channel with their trainer. Only P2 mentioned discussing Salud! with her trainer, and that was only to set the expectation that she did not expect to be using it for communication or related purposes.

> We kind of agreed that it just – it didn't work for our particular thing just because, you know, we would just talk directly, rather than sort of communicating through the application. *–P2*

It's worthwhile to note that every message sent by a trainer through the Chat Logbook was read by the GT Biggest Loser contestant to whom it was directed. Only announcement messages (which trainers sent to each team member) were directed at static non-users, however. Contestants were notified of new messages in the Chat Logbook by an automated Salud! email.

Feedback about Salud! Functionality

In addition to the four categories discussed above, a common theme found in interviews was feedback and requests about Salud! functionality. In this subsection, I present some the three most common, non-trivial features or functionality changes that participants requested. These additional findings serve to increase understanding of how participants wanted to use the application: participants in different user profiles requested different functionality. The findings presented in this subsection may also be useful as design considerations for other designers working in this space.

The most commonly requested feature overall, and also the most requested by casual users and static non-users, was the ability to lookup and save the nutritional content of different foods. All GT Biggest Loser contestants used a food log, and none of the casual or static non-users in that cohort used the Salud! Nutrition Log for that purpose. Instead, they used a third-party website, such as FitDay or SparkPeople, which allows users to search for foods and add them to a meal log. The site maintains an up-to-date nutritional database that it uses to populates the user's nutritional intake breakdown.

All participants who requested nutritional integration felt that they would be doing unnecessary work if they looked up the calorie information on such a site then to only enter the calorie data into their Salud! account. Interestingly, however, none of the enthusiastic users strongly requested this feature. All had used the Nutrition Log

Logbook: three had appropriated it to their liking, or created additional Logbooks to track additional, personally relevant variables; one suggested nutrition-lookup functionality only during the concluding meeting, but as a time-saving feature rather than a must-have.

The second most commonly requested functionality change was improvement of the analytics features. I received requests of this type from several enthusiastic users and casual users, as well as two trainers. One common suggestion was the ability to filter, sort, and search data entries in a Logbook's table view. Some users also requested the ability to create scatter plots by allowing both the X- and Y-axes to be column values (in Salud! the X-axis is always a timeline). T2 requested additional analytics features so that he could show some of the relationships to his clients—not for his own analysis. He felt that seeing a plot of data such as sleep length vs. training performance or stress vs. calories consumed would provide his more difficult clients with more jarring evidence for why they needed to change their habits.

The third most popular feature request came from GT Biggest Loser contestants in the static non-user, progressive non-user, and casual user profiles. These participants suggested different ways in which Salud! could integrate better with were GT Biggest Loser program. For example, several suggested including a calendar or other planning tools, to make scheduling easier. Another common request was to make it easier to enter group fitness classes (for points). This underscores that these contestants experienced the Salud! application as a display of their progress, not as self-tracking tool.

Discussion

An important result that emerges from the findings presented above is the importance of attitude toward self-tracking and the attitude towards goals in effective use of a personal informatics application. Most of those participants who oriented themselves toward specific, short-term goals and were comfortable quantifying their experience or practices were successful in integrating the Salud! into their daily routine. Conversely, participants who acknowledged that they were not interested in quantitative self-tracking at this stage in their lives did not make much use of Salud!

It's self-evident that a balanced, healthy human experience needs qualitative and subjective goals. However, I have already presented in Chapter 2 that, for many types of goals related to health and wellness, objective goals that are short-term and actionable work best for realizing the goals (c.f. [74]). This study provides some additional evidence for that statement. Individuals who do not wish to set quantitative goals, whose goals are difficult to objectify or quantify (e.g. "improve gymnastics performance"), and individuals who are not *yet* setting Action Plan-like goals may also benefit from technological systems to support them in realizing their goals. However, the results of this study suggest that a personal informatics application like Salud! does not seem well-suited for the job.

It is worthwhile to reiterate that one of the key survey metrics I used when classifying participants across profiles was *reported* progress towards their goal(s). An argument can potentially be made that participants who were casual users actually did make significant progress on their goal, but did not recognize the progress because they were not tracking the appropriate metric. The human mind is not good at recognizing change related to health and fitness within the body: the pattern of such change is slow, multi-faceted, and requires long-term, accurate historic data to establish. The lack of accurate historical data is especially problematic, as evaluating this type of progress from memory can introduce substantial biases [7]. Thus, using Salud! may have been a reinforcing function for those participants who used it regularly during the deployments: they improved during the course of the deployment *and* were also able to see the improvement as historical data in their account.

Perception of Communication

An issue I had not considered before analyzing the deployment data is how transparent Salud! is about login and use patterns between participants and facilitators. There were participants in the enthusiastic user, casual user, and static non-user profile categories who, within a week or two, established that their trainer was not using Salud! at all, or at best very infrequently. This is because these participants' trainers had promised to enter data into their account, and the users were able to see how the data appeared (if it did at all). While enthusiastic users were not demotivated if they learned that their trainer was not logging on frequently, for some casual and static end-users this was a significant reason for why they did not use the application as well. On the other hand, P4 was motivated at least in part due to the fact that she believed that her trainer was reviewing her data (the trainer separately acknowledged doing this only rarely). These two facts point to an interesting takeaway, which is that some level of ambiguity with respect to use patterns may be helpful in encouraging longer-term use of personal informatics applications where multiple individuals share data (c.f. [1,31]).

Toward Support for Goal Management

The Salud! application, as it was deployed in the studies described in Chapter 4, allows an individual to track a wide variety of personal data. It then supports the user in reviewing and analyzing this data using straightforward analytics features. The feature that notably separated Salud! from other personal health informatics applications is the ability to share data with a facilitator—a personal trainer, nutritionist, etc. who can help the user understand and make the most of the collected data. This feature mix allowed me to collect the qualitative data analyzed in this chapter. The results of this analysis provided design requirements for a goal management interface that would be compatible with Salud! and the ways it is used in real-world, facilitated fitness contexts.

These results are integrated into a description of the goal management process in the next chapter. This description provides a coherent set of design requirements for building a goal management interface. To design an interaction that both anticipates real-world practices and conforms to Action Plan-based goal management strategies described in Chapter 2, I integrate the two sets of requirements into a model of the goal management process. This model is developed and presented in the following chapter.

A key result that guides the creation of the goal management model is the varying level of Salud! use, related to whether or not a participant incorporated Action Plans into their practice. However, the experience of static non-users, such as P2, shows that articulating goals is a personal meaning-making process that can shift over time. As such, it is important to keep in mind that the model described in Chapter 5 is not a one-size-fits-all result. It is specifically focused on quantitative, actionable, short-term goals, as described by Action Plans. Whether or not an individual chooses to set this type of goal is ultimately a personal decision.

CHAPTER 5

A GENERALIZED GOAL MANAGEMENT INTERFACE

The Salud! application, as described in the previous chapters, does not have any dedicated functionality for managing, evaluating, and realizing personal goals. Users track the goals implicitly as they enter data and go about their fitness/wellness practice. The application does not allow users to articulate goals, nor does it support them in setting or adjusting their goals. However, this dissertation is ultimately focused on extending personal informatics applications to support goal management using evidence-based strategies utilized in Health Self-Management (HSM) interventions and educational programs. Indeed, Chapter 2 listed five such strategies that can be implemented in personal informatics applications such as Salud! Additionally, the findings presented in Chapter 4 provide a substantial foundation for creating a goal management interaction that should be applicable to a range of goal types.

In this chapter, I present a generalized goal management interface that I have designed during and after the deployments described in Chapter 4. The interface allows knowledgeable individuals working alone, or individuals working together with a facilitator (e.g., a personal trainer, nurse practitioner, or other trusted expert) to define and set a broad range of goals and evaluate progress over time.

In order to create a generalized interface that supports self-defined goals, I modeled goal management practices, as they are described in psychology and health education literature, and as they were performed during the field deployments of Salud! described in Chapter 4. This model is defined by three components: representation, visualization and evaluation. I also present this model as a starting framework for other researchers and practitioners who are developing systems with personal goal management interfaces. At the end of the chapter, I discuss the limitations of this model, and how future work may be able to expand it to a broader range of more complex goal management interactions.

Background and Related Work

There are a host of commercial systems, such as Fitbit and Mint.com, which provide specific goal management features to end-users. Various research systems have also been developed to support individuals or groups in meeting everyday goals, usually related to wellness (e.g., [22,55]) or sustainability (e.g., [32]). These systems support goal management interactions with respect to a *fixed, single goal* or a set of *fixed, related goals*. I extend on this work by presenting an open-ended system that can be used to support goal management for a broad range of custom, user-defined goals.

Recently, some researchers have begun addressing the design of goal management applications more generally. Consolvo and colleagues have written about trade-offs in goal setting strategies for applications that encourage physical fitness [20]. He and colleagues have discussed theoretical applications of general behavior change theories to eco-feedback (sustainability-related) systems design [46]. I have also published the set of goal management strategies presented in Chapter 2 of this dissertation for consideration by designers of systems that support healthy behavior change [68]. Taking these works as a theoretical foundation, I designed a generalized interaction for goal management. The interaction is consistent with the goal management processes presented in this previous work, and also relies heavily on understandings of *in situ* goal management built up during the deployments of Salud! with GIT FIT participants and GT Biggest Loser.

In addition to the HCI litearature, personal goal management has received a great deal of attention from many domains of psychology and medicine (e.g., [4,13,56]). These investigations have informed the designs and theoretical work noted in the previous two paragraphs. They also directly inform my design by allowing me to embed effective goal management strategies into a gol management model that is compatible with interactive, computational systems.

Specification and Design of a Goal Management Interface

As already noted, existing systems that support personal goal management are designed specifically to support one type of goal or a specific set of related goals. My intention was to design a goal management system that was compatible with the open-ended nature of Salud!'s Logbooks. To be an effective component of Salud!, the goal management interface would need to be able to handle the customized Logbooks users create to track and manage their self-defined goals. The key features of Salud! that differ from existing systems are open-ended data collection and the availability of visualization and data analytics that handle a variety of data. I briefly describe the relevant features of Salud! before presenting the generalized goal management model.

Synopsis of Relevant Salud! Features

Salud!'s data collection component allows an individual user to select or define a variety of Logbooks for personal data that she would like to track. For example, a user can track her own body weight by using the provided Weight tracking template. This template allows the user to enter timestamped numerical values (weight measurements) along with text notes. The user can also define her own Logbooks (see Figure 1a); for example the user can create a Logbook called "Fast Food Meals" where she can track visits to fast food restaurants. Logbooks are completely customizable, so the user could decide to track the restaurant name and the approximate amount of calories in the meal; or to track the meals using a custom tagging system (e.g., "healthy" or "unhealthy") and photo of the meal. This flexibility of data representation makes it impossible to simply specify a set of pre-existing goal types. Depending on the user's preferences, a similar outcome can be tracked in a variety of ways (e.g. "decrease number of restaurant visits" vs. "increase number of meals cooked at home").

The data collection component is integrated directly with a simple set of visualization and analytics tools. Users can review and edit the data in their Logbooks in a table or graph (see Figure 5.1). It is also possible to graph data from different Logbooks side-by-side (see Figure 5.2). Please refer to Chapter 3 (or [67]) for a detailed discussion of Salud!'s data collection component and the visualization component.

Goal Management Component Overview

The purpose of the Salud!'s goal management component is to allow a user to set and manage a goal with respect to any of the Logbooks in her account. For example, if the user is tracking her body weight in the Weight Logbook, she is able to set and manage a goal for her weight; if she is tracking her visits to fast food restaurants in her custom "Fast Food Meals" Logbook, she should be able to set a goal related to that—for example, to decrease the frequency of visits.

The rest of this chapter describes the functionality, design, and user interface of this component. In the next section, I discuss the model of goal management that I developed as the basis of a general goal management interface. Then, I describe the interface and how the interface follows from the model. I finish by presenting some limitations of the current model (and interface) and suggest how it can be extended in future work.

Generalized Goal Management Model

In order to design for a general goal management interaction, I had to develop a model of the goal management process compatible with a personal informatics application like Salud! While setting and managing a single goal, such as walking at least 10,000 steps per day (a common fitness goal [87]), seems straightforward, goal management in general involves many moving parts. Even considering only quantifiable, personal goals that can be set and realized within the timeframe of at most several years, there is a lot of variability. Consider the differences between the following two scenarios (I will return to these scenarios several times in the course of the chapter):

1. Alice currently weighs 161 lbs (73 kg) and would like to lose 10 lbs (5 kg). She already goes for short jogs several times a week. However, Alice would now like to increase her jogs from 10-15 mintues to 30.
2. Bob visits his favorite steakhouse five or six times a month with his friends. Because he was recently diagnosed with high cholesterol, however, he decides to cut back on unhealthy restaurant meals and eat at home more often. He's not ready to change his ordering habits at the restaurant, so instead he decides to reduce his visits to no more than twice a month.

Bob's goal is about the number of times an event occurs. It's an infrequent event that Bob considers in monthly terms. Also, he can choose to reach his goal gradually—minimizing the potential impact on his social life—or all at once. On the other hand, Alice's goals imply a daily or weekly timeframe. They are goals about measurement values (rather than the frequency of the measurements). Finally, they require gradual change over time: losing more than 2 lbs per week, for example, is generally considered unhealthy and unsustainable [42].

Successful Goal Management Strategies

Considering this variety of potential goals that I wanted to support, I looked to existing research literature to understand how goal management processes have been successfully implemented—both in software and in non-technical settings. Following this literature review, which is presented in detail in Chapter 2 (and also [68]), I developed a general model of the goal management process, which I could use to structure the interaction design. The three components of this model are:

1. **Representation**: The operational definition of a goal and its underlying data stream (weight measurements, timestamps of restaurant visits, etc.).
2. **Evaluation**: A recurring event during which the individual's performance is evaluated and the goal is adjusted appropriately.
3. **Visualization**: The way in which feedback about performance with respect to the goal is provided.

It is important to note several things about this model. First, it is meant to be congruous with computational systems and software-based interactions. The goal's representation will allow it to be unambiguously determined whether it has been met or not (either automatically or through human judgment). The evaluation component implies a recurring event during which the individual's performance is evaluated. This means that goals have targets, which may change over time based on the individual's performance. Finally, the separation of visualization as a distinct component of the model means that the goal does not have to be represented literally in terms of its evaluation criteria. These implications are in line with the best practices suggested in [20,68].

Generalized Goal Management Interface

Using the above model as a framework, I designed a set of interactions (and corresponding interfaces) that allow a range of goals to be defined, set, and managed. In this section I present the model components in greater detail and discuss how the interactions and interfaces I developed address their requirements. In many instances, my concrete implementation is not only way that the requirement could have been addressed. Where appropriate, I will discuss why I made certain design decisions and how they could be implemented differently by researchers or practitioners working under a different set of constraints.

The Role of a Facilitator

Salud! is meant to allow users to manage self-defined goals. As such, it has no semantic information about any specific goal. Instead, the user or a knowledgeable administrator (facilitator) specifies the appropriate attributes of particular goals (e.g., the "aggregation operation" or "adjustment step," discussed below). The facilitator can be an individual who is familiar with a user and her goals, such as a personal trainer or a health educator. In the future it may be possible that a user could be able to set all of her or his goal attributes. At the current time, however, using the facilitator interfaces is significantly less intuitive than the other parts of the application, due to the technical nature of the goal management model. As such, it is not made available to end-users.

The facilitator's role is completely circumscribed by the model of the goal management process and its implementation in our system. For any specific goal, facilitation can be completely automated. However, as we allow each user to create custom goals, our system requires a human in the loop to interpret the semantics and intent. A human facilitator such as a personal trainer can also adjust goal attributes based on domain knowledge and personal experience, rather than following the same script for everyone. In this way, the facilitator acts much like the "wizard" in system utilizing Wizard-of-Oz evaluation [25].

Model Component: Representation

A goal's representation is a set of attributes that concretely specify how it will fit into the goal management interfaces. These attributes are its goal-status, underlying data string, temporal targets and aggregation operation.

<u>Goal-Status</u>

The most basic aspect of a potential personal goal is whether it makes sense for it to be a personal goal at all! Salud! users are free to track things such as local temperature, pollen count, etc. While they may be represented in the same way and displayed side-by-side with personal data about the user, one cannot set personal goals about them. For this reason, a facilitator can take away a data stream's goal-status, in which case it will be removed from its user's goal management features (see Figure 5.3).

Data Stream

Fundamental to a goal is the temporal sequence of data—measurements, self-reported values, etc.—about which it is set. As discussed previously, in Salud! a data stream (Logbook) is a timestamped set of zero or more numerical values. Alice's Weight Logbook might be a sequence of data, with each datum having a timestamp, a weight measurement, and optional text note. Bob's Steakhouse Visits Logbook may be only a sequence of dates on which he ate at his restaurant. Or it may be a timestamped sequence of photographs of his meals with text descriptions. Salud! gets its flexibility to support many kinds of goals from the fact that users can create and customize their own data streams (see Figure 5.1).

Aggregation Operation

A goal's aggregation operation specifies how multiple data points in its data stream are considered. This is a key semantic aspect of the goal, and must be specified by the facilitator. For example, weight measurements (such as in Alice's Weight Logbook) must be averaged together. It does not make sense to add weight measurements, or perform other types of mathematical operations, to look at weight on a weekly or monthly timeframe. On the other hand, her weekly jog times could be averaged (if she is trying to increase her jog length) or summed (if she is trying to increase the overall length of time she spends jogging). In cases like this, the aggregation operation can change based on the user's intent.

I have implemented four basic aggregation operations in Salud!: SUM, AVERAGE, COUNT, and OUTLIER-COUNT. COUNT simply measures an event's frequency. It is the only simple operation that is available for Logbooks like Bob's Steakhouse Visits. The OUTLIER-COUNT aggregation operation is used for goals related to keeping values in a range. These are very common health goals: individuals with diabetes usually have a goal about the range in which their blood glucose value should fall; individuals with hypertension similarly have a goal for systolic and diastolic values of their blood pressure. Thus, OUTLIER-COUNT measures the number of times a regularly occurring measurement falls outside of a predetermined range.

Temporal Targets

The last component of a goal's representation is its set of temporal targets. Temporal targets specify how the user wishes for the data stream to change in the future. It captures the common definition of a personal goal—a specific change in actions or outcomes.

Each temporal target is a timestamp and a desired value for the data stream (or the aggregator function applied to the data stream). Alice may have a single temporal target: a weight of 159 lbs in one week (a loss of two pounds). Or she may have multiple targets: 159 lbs in one week, 155 lbs in one month and 151 in two months. Bob's temporal target may be: no more than four visits to a restaurant over the next calendar month. Additionally, users may set a long-term target, which is their ultimate goal. The long-term target doesn't need a future timestamp. It's simply a reminder or context for what the user is trying to accomplish at some as-yet-unspecified point in the future.

In Salud!, users set a long-term target, and have one future temporal target. As each temporal target passes, the user is provided with feedback on her performance (see next section) and asked to set a new temporal target. The interface focuses the user's attention on the current temporal target (see Figure 5.2c). A goal's long-term target is only visible when the user is editing it. This design choice stems from research results that suggest that setting and focusing on short-term goals is more effective than setting and focusing on long-term goals (which can seem daunting and discouraging).

Model Component: Evaluation

The second component of the goal management process model is evaluation. Evaluation occurs when a temporal target is reached. At this time, the user's performance of the temporal target is evaluated and, if necessary, future temporal targets are set or adjusted accordingly. This process allows the user to set short-term goal targets, evaluate her performance (or have it evaluated by a facilitator) and adjust her sights accordingly. The objective of this process is to gradually (and “sustainably”) bring the user closer and closer to her ultimate goal (see Figure 5.2c) [56,68]. The evaluation process is also where the contribution of a human facilitator (rather than an automated process) is most apparent. Individuals have different capacities with regard to how much they want to be challenged, over-coming difficulties, etc. A skilled and experienced human facilitator can match the evaluation process to a user’s needs, whereas an automated system (unless it is highly sophisticated) is going to apply the same process regardless of user.

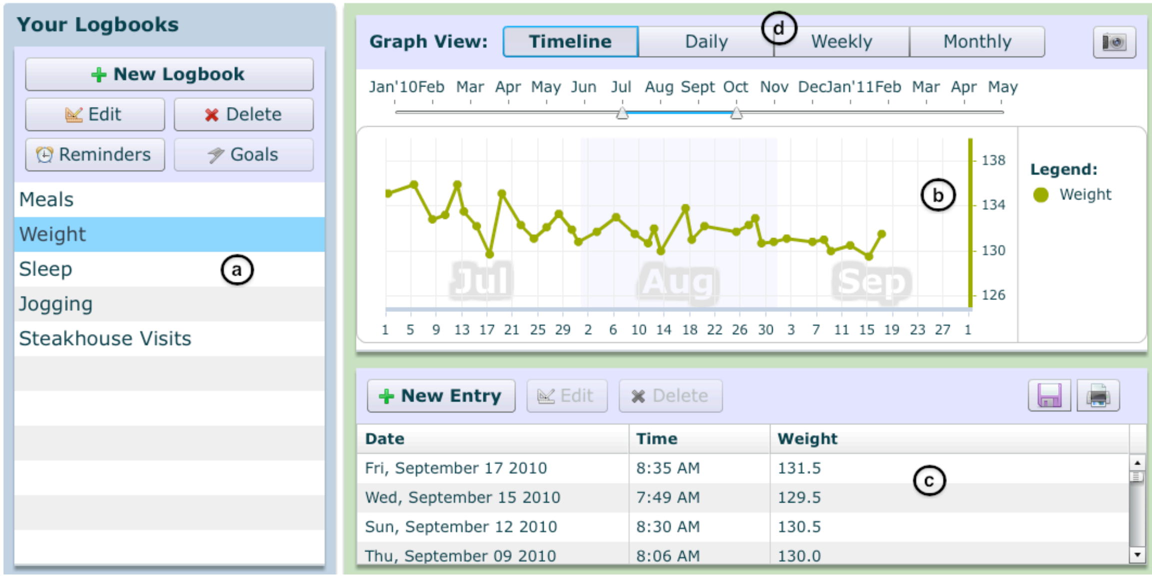

Figure 5.1. Sample Salud! user account. (a) The user's Logbooks; (b) the graph visualization of the selected Logbook; (c) table visualization of the selected Logbook; (d) visualization timeframe options.

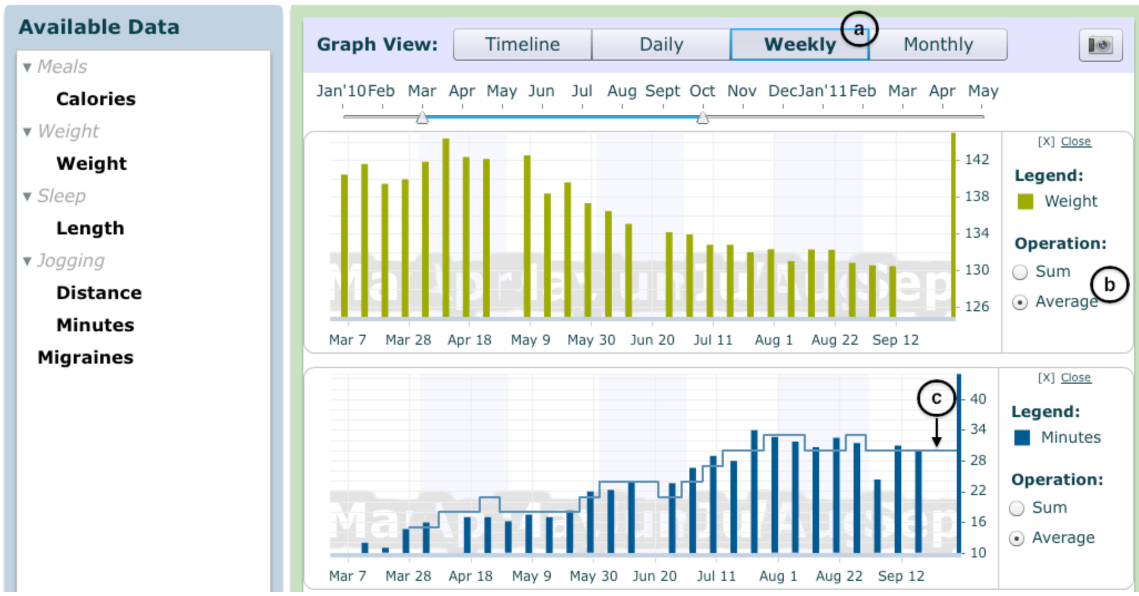

Figure 5.2. Analytics view, showing two Logbook columns (Weight, and Minutes jogging). A goal is set on the Minutes column. (a) The goal's visualization timeframe is selected by default; (b) available aggregation operations, with the goal's default operation selected; (c) line showing past and current goal targets (evaluated weekly).

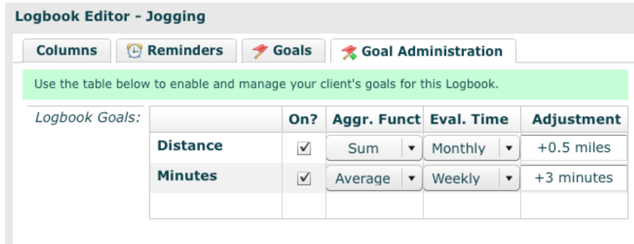

Figure 5.3. Facilitator's goal administration interface, showing a Logbook which includes Distance and Minutes values for each data point. The columns, from left to right, are goal-status, aggregation operation, evaluation timeframe and target adjustment.

Evaluation Timeframe

The evaluation timeframe refers to the temporal window of data points that is considered at each evaluation. In some cases, the evaluation timeframe may be simply the last available data point. However, for most goals, the window starts at "now" (which is the timestamp of the temporal target that triggered the evaluation) and goes back some number of hours, days, weeks, months, etc. The aggregation operation is then applied to all of the data points that fall in the window. In Alice's case, her Weight evaluation timeframe is one week, so that at each evaluation the average of her last week of weight measurements is used to determine whether she achieved her goal target or not. Bob's restaurant visits evaluation timeframe is one month; as each temporal target is reached (e.g., the beginning of a calendar month), the COUNT operation is applied to the data points of the previous month. As with the aggregation operation, the evaluation timeframe should be set with regard to a user's intent when she or he sets a goal.

In Salud!, the available evaluation timeframes are one day, one week and one month. These are easy to understand and can be set by the end-user when first creating a goal. The facilitator can also set or adjust the evaluation timeframe (see Figure 5.3).

Target Adjustment

After each evaluation, the user should be encouraged to adjust her future temporal targets, if appropriate (or, depending on the system, the adjustment could be performed for her automatically). For example, if Alice does not realize her weekly jogging target, it may be pertinent to adjust it downward, as the current target may be unnecessarily challenging. On the other hand, if Alice soundly beats her jogging target, it may make sense to revise upward. The value by which a temporal target is revised is the target adjustment. It creates a "step up" or "step down" for the user on the path to her eventual goal. This sequence of steps that gradually takes the user from her current position to her ultimate goal is an important aspect of successful goal management practices [4,68].

The facilitator is responsible for setting and adjusting the target adjustment (see Figure 5.3). In setting this value, she may consider her experience with the user (if any) and/or experience with similar goals. However, there is also substantial literature on goal adjustment practices (e.g., that weight should be lost between 1-2 lbs per week [42]) that could inform an automated system to set this value for a set of pre-considered goals.

Adjustment Function

In addition to the target adjustment value itself, an adjustment function is required to ascertain whether it should be suggested to the user to adjust her target. This function specifies the cutoff values or the conditions under which the user will be asked to increase, maintain or decrease her temporal targets. For example, if Alice's current temporal target was for an average jog length of 20 minutes, and her actual performance was 19 minutes, should she maintain her goal? Or is the performance good enough that she should try to increase? The answer may depend on Alice herself, her history of performance with regard to this goal, and the purpose and design of the application.

In Salud!, the facilitator is tasked with selecting whether it should be suggested to the user that she should increase, decrease or maintain her next temporal target.

Missing or Incomplete Data Strategy

A key aspect to consider as part of the design of a system with goal management features is how to handle evaluation in light of missing or incomplete data. Over time, users are likely to forget to measure data, forget to enter data, or forget to use the sensor that is supposed to automate data entry. It is necessary to plan for this case during the evaluation event, especially if it will be done automatically.

Goals where summing is required (e.g., daily calorie consumption) are especially susceptible to the problem of missing or incomplete data. Users frequently forget to log meals and snacks—however it does not necessarily mean that they have not eaten or that they are realizing their goal. The designers of such a system should consider whether to filter certain data patterns, use an average to replace missing data, or handle the issue in some other way. If no data is available at all for the evaluation timeframe, it may make sense to simply continue the previous temporal target forward. However, in some cases it may mean that the user has abandoned the goal because it is too challenging, and in this case a downward revision by one or two target adjustments may be warranted.

Salud! relies on the human facilitator to act as appropriate when evaluating a user's performance with respect to a temporal target where there may be missing or incomplete data in the evaluation timeframe.

Model Component: Visualization

Visualization is the last component of the goal management model I present in this chapter. Attributes of visualization specify how the user's data stream is to be presented for display. Effectively, the visualization allows the user to receive feedback on her performance with respect to any approaching temporal targets. If past data is presented as well, she can also see her history of performance and how it has changed. Visualizing her data allows the user to plan ahead or take action to ensure that she meets her goal.

Visualization Type

The goal's visualization type refers to the way in which the data stream will be presented to the user. Common visualization types include table and graph. However, many research systems provide a unique or novel visualization type in order to evaluate its effectiveness at conveying information or motivating action (e.g., [22,32,55]).

Because Salud! is mean to be general, it provides basic table and graph views of the data to the user. The table presents a user's data stream in a nearly-universally understandable way, and allows for easy adding and editing of self-report data. Graphs provide a more compact display of data and can also display the output of aggregation operations (see Figure 5.2b). If a user's data includes images, they can be displayed by hovering over the appropriate row in the table or point on the graph.

Visualization Timeframe

The visualization timeframe specifies how (and if) data points are bucketed for display. It may be the same as the evaluation timeframe in many cases. However, whereas the evaluation timeframe can only be relative to "now", the visualization timeframe can represent calendar weeks (starting on any day of the week) or calendar months. If a visualization timeframe is not applied, the data can simply be displayed on a timeline, with each data point on its timestamp. It is optional to allow the user to change the visualization timeframe dynamically (to get a different perspective on the data).

Salud! provides straightforward graph-based visualizations. A facilitator can specify a default visualization timeframe, but the user is able to change it when viewing her or his data (see Figure 5.1d, 5.2a). The user can also select how many months of data are displayed on the screen. This is very different from a system like Ubifit, which shows the user's data stream only for the last calendar week, and this timeframe cannot be changed. Considering the visualization timeframe within the design process can allow system developers to ascertain which functionality is right for their requirements and users.

Target Visibility

The final aspect of visualization is displaying the user's temporal targets. The targets that can be shown are past targets (if any), current short-term targets and the long-term target (if set). Displaying the past targets allows the user to see her history of performance with respect to the goal. The short-term targets provide actionable advice about actions that should be taken in the near-term. For example, Bob's short-term target for restaurant visits can help him plan meals and social activities in order to achieve his goal. Finally, showing the long-term target can provide context and motivation to keep working on the short-term targets.

In Salud!, the user's past targets are overlaid on the Logbook visualization. Only the future short-term target is shown on the visualization, however. The long-term target is not shown on the visualization and is only available in the goal management interface (see Figure 5.2c). I made this design choice to focus the user's attention on the task-at-hand, rather than her proximity to or distance from the long-term target (which may be discouraging if the target is very far). This focus on the short-term target is supported by our review of successful goal management strategies. However, this design choice may need to be considered differently in other systems with goal management features, and so we highlight it as part of our model.

Limitations of the Model

The goal management interaction model presented here, though applicable to a broad range of personal goals, has several important limitations that I discuss in this section. These limitations have not prevented me from using it as the foundation of a generalized goal management interface that fits my specifications, but they may be important to researchers and designers working with different constraints. I expect to begin addressing these limitations as I continue developing Salud!'s goal management component, and hope that other researchers working in this domain may also address them.

In the model presented here, each goal is treated separately and its management process is unrelated to other goals. In reality, goals are often related. For example, Alice sets her jogging goal to help her reach her weight goal. Whether or not she is realizing her jogging goals (along with other factors) is expected to impact whether or not she is realizing her weight-loss goal. This relationship may affect how these goals are evaluated, or could be utilized to improve the visualization. More generally, goal relationships are utilized in successful goal management strategies to set actionable goals (activities such as calorie intake or fitness targets) related to non-actionable goals (measurements such as body weight or blood pressure) [68]. However, relationships between different goals are not considered in the current model.

Goals often have a social component. Indeed, research systems frequently share individual goal performance among a group, or set group goals in addition to (or instead of) individual goals (e.g., [55]). The model presented in this chapter is based on research about individual goals, and does not address social aspects of the goal management process.

Finally, incentives and persuasion can play a role in goal-oriented applications [20,30,46]. The model I present does not currently address these potentially important facets of the goal management process.

Practical Applications and Evaluation

The goal management interaction presented in this chapter allows an end-user and her facilitator to create and manage goals related to data collected and stored in Salud! The flexibility of Salud!'s data representation, combined with the generality of the goal management model, provide users with the opportunity to manage a relatively wide variety of personal, health-related goals. These can include calorie intake, amount or exertion of exercise, patterns of actions or activities, and so forth, as long as the goal can be represented within the constraints imposed by Salud!'s data structures and the goals' targets and other evaluation parameters are compatible with those encoded into Salud! However, the breadth of possibilities means that the human facilitator needs to input a goal's semantics and visualization attributes into Salud! each time that a goal is created, and make certain decisions during performance evaluations.

The facilitator has a limited set of options available for each variable in a goal's representation, evaluation, and visualization components. This limitation of options (which is what makes the model compatible with a computational system) also means that decisions can be pre-programmed or scripted. Given a specific goal, it is possible to encode some or all of the decisions that go into its execution into an automated script. Like the rest of the Salud! application's functionality, all goal management functions are exposed through an API (as discussed in Chapter 4). For this reason, the coded interaction can be literally scripted, using API calls to perform the actions that would otherwise be performed by a human user in the UI. The ability to automate facilitator actions is one of the main opportunities of the goal management model: It can be used to automate or semi-automate a goal management strategy, provided that it contains components simple enough to be represented in software logic.

In the following chapter, I leverage the ability of Salud!'s goal management system to be automated to evaluate its effectiveness. Through this functionality, can deploy the application to a large number of participants, allowing for a statistical evaluation. The hypothesis evaluated is whether the goal management interface described in this chapter is indeed more effective than a simpler, naïve goal management interface.

CHAPTER 6

QUANTITATIVE EVALUATION OF SALUD!'S GOAL MANAGEMENT INTERFACE

This chapter presents a quantitative evaluation of Salud!'s goal management interface. The interface was built based on the Generalized Goal Management model presented in the previous chapter, the objective of which is to integrate effective health self-management (HSM) strategies into the goal management interaction. I evaluated the interface's effectiveness as compared to a basic, simple goal management interface. Based on the work presented previously, the hypothesis of this study is that Salud!'s goal management interface is more effective than a simple goal management interface that does not utilize Action Plans or lessons from the deployments analyzed in Chapter 4. Stated more specifically, there are two hypotheses about Salud!'s goal management interface:

1. Using Salud!'s goal management interface will increase the probability of an individual realizing a specific fitness, compared to a basic goal management interface;
2. Users of Salud!'s goal management interface will be more engaged with a fitness intervention, as measured by number of days logging data, compared to users of a basic goal management interface.

There is an additional research question that is answered as part of this evaluation, which is: What demographics and population factors predispose individuals to being more likely to realize a fitness goal using the Salud! goal management interface.

I compared the effectiveness of the two interfaces based on a straightforward, easily quantifiable goal: Increasing daily step count over the course of several weeks. This is specific goal, and thus can only provide evidence for or against evaluating the hypothesis in this specific context; it cannot evaluate the hypothesis as stated broadly. Nonetheless, the results of this study provide useful data regarding Salud!'s goal management interface, and also provide guidance for how its effectiveness may potentially be improved.

Pedometer studies also form a common type of quantitative study performed to assess the effectiveness of HSM programs. Thus, another contribution of this study is to compare how effective a personal informatics system can be in supporting individuals in walking more, compared to traditional HSM interventions.

This chapter's first section provides background about pedometer goal settings studies, as they have been performed so far. I then describe the interface that was evaluated, and the simpler goal management interface that was used by the control group. Deploying these two interfaces allowed me to address the following research questions:

1. Can an automated fitness intervention increase participants' step counts? How does it compare to HSM interventions described in existing research literature?
2. Does a goal management interaction based on HSM strategies improve the effectiveness of the intervention, as compared to a simpler goal management interaction?
3. Is the automated intervention better suited to certain demographic factors? These factors are age, gender, general self-efficacy (GSE), and pre-intervention activity level.

Results of the study and a discussion of their implications for the design of further goal management interface conclude the chapter.

Study Background

There has been recent interest in the HCI community regarding computational systems that promote healthy behavior or encourage physical activity. Though devices and applications in this category have been deployed in a variety of contexts, there is substantial focus on systems for "everyday" settings (e.g. [19,22,55,86]). These systems generally work by allowing an individual to record some physical behavior (or monitor it automatically), and then present encouraging feedback back to the individual. In many cases, pedometers are used to collect activity data, due to their, availability, ease of use, and demonstrated effectiveness [87]. Users' step counts can then be recorded, visualized and/or shared in a variety of ways.

Increasing individuals' physical activity is also a concern in medical and health policy literature. A variety of pedometer-based health interventions have been conceived and evaluated in clinical and healthcare settings. These interventions are most frequently aimed at individuals with chronic illness (e.g. diabetes), or those who are at risk for developing health problems due to overweight or a sedentary lifestyle. Recent meta-analyses of this body of work shows that pedometer-based interventions are indeed broadly effective at increasing physical activity and improving health outcomes such as Body Mass Index (BMI) and blood pressure [15,76].

Most health/wellness interventions presented in both the HCI and the medical literature tend to be *high-touch*—i.e. involving substantial human resources and interaction. The systems presented in the HCI literature are often one-of-a-kind design explorations and their evaluations involve many interactions between participants and researchers (e.g. interviews). In the medical literature, the fitness interventions presented are often only available to individuals living with or at risk for chronic illness. Many are provided as part of broader health programs, with substantial involvement from medical staff, educators and community organizations [15]. These factors doubtlessly contribute positively to a health/wellness intervention; attention from professionals can increase the effect and sustainability of behavior change [13,58]. Additionally, qualitative data collected by HCI researchers can provide a rich and meaningful evaluation of a prototype system. However, most individuals do not qualify to participate in clinical health programs; researchers' and professionals' time is usually very limited; and research systems are only available to a small number of participants (especially if custom hardware is required).

One of the goals of this chapter is to evaluate the effectiveness of a *low-touch* wellness intervention—one that's automated, requires few direct interactions between researchers and participants, and uses a web-based application (Salud!) with off-the-shelf hardware. The purpose of this chapter is twofold:

1. To provide a baseline metric for the effectiveness of a simple, automated and pedometer-based intervention developed as part of the Salud! application.
2. To serve as a model for similar interventions that can leverage technology and design to scale broadly and cheaply to large populations.

To accomplish these goals, I ran a wellness intervention based on increasing participants' step counts. The intervention was intended to fit into the existing routines of a large and varied participant population, and to run in an automated fashion. The intervention included a randomized, controlled trial (RCT) to compare the effectiveness of two versions of Salud!'s goal management interaction. One version of the interaction was based on the construct of Action Plans (discussed in previous chapters, but also summarized below), while the other was a simpler, fixed-goal interaction. The three research questions that guided this work were:

1. Can a low-touch, automated fitness intervention increase its participants' step counts? How does it compare to high-touch interventions described in existing research literature?
2. Does a goal management interaction based on Action Plans improve the effectiveness of the intervention when compared to a simpler goal management interaction?
3. Is this type of intervention better suited to certain demographic factors? I specifically examine age, gender, general self-efficacy, and pre-intervention activity level.

The rest of this chapter is structured as follows: First, I outline the related work that led to these research questions and intervention design. I then describe the intervention procedure and the two software configurations of Salud! that I tested. I then present the quantitative findings from the intervention: its overall effect on the participants, the difference in effects across conditions, and the difference in effects across participant subpopulations. In the final section, I discuss the significant patterns in our findings and contrast these results with previous work. I conclude the chapter by by commenting on how this work is situated in the broader context of contemporary HCI evaluation methodologies.

Related Work

Medical Literature

There is a substantial amount of research in the medical literature about pedometer-based physical fitness interventions. Two recent meta-analyses make a compelling case that these types of interventions are effective at increasing participants' daily step counts [15,76]. Bravata et al. found that, pedometer-using participants in 8 randomized, controlled trials (RCTs) increased their step count by an average of 2491 more steps per day, compared to participants in control conditions who did not use a pedometer (95% confidence interval [CI], 1098-3885). In the same meta-analysis, they found that participants in 18 observational studies increased their daily step count by an average of 2183 steps per day over their baseline, once they started using a pedometer (95% CI, 1571-2796) [15]. In a separate meta-analysis of 9 studies, Richardson et al. report step count increases between 1,827 and 4,556 [76]. Both meta-analyses found small but statistically significant improvements in participants' health outcomes as a result of pedometer use, including decreases in BMI and blood pressure [15,76].

HCI Literature

The HCI research literature contains a variety of evaluations of computational systems that encourage physical activity. Fish'n'Steps [55] encouraged participants to walk more by tying their performance to the status of a virtual aquarium. In its evaluation, participants increased their physical activity by an average of 1332 steps per day [55]. Chick Clique [86] and Houston [19] both used social sharing to encourage individuals to increase their daily step count. However, the main contribution of both projects was the system design, and only a preliminary evaluation was provided. Ubifit Garden [22] used an engaging visualization to encourage individuals to increase their level of physical activity. While evaluation participants reacted positively to the system, the results did not include a comparison of pre- and post-intervention physical activity metrics. Research has also shown that video games with a physical activity component can encourage physical activity (e.g. [8]). In many of these investigations, participants are reported to be engaged by or to become attached to the prototype systems after short periods of use [21,22,55,86].

However, little quantitative evidence has been collected about the effectiveness of computational systems at increasing physical activity over longer periods of time. Without this evidence, it is difficult to evaluate the benefit of additional design elements such as gamification or persuasive strategies. It also makes it challenging to engage in discussions with research communities where quantitative, outcome-based results are normative (c.f. [33,50]). In this work, I am beginning to address this gap by providing a baseline measure of the effectiveness of computational interventions.

Differences between Medical and HCI Literature

Most medical interventions target older adults (mean age of participants in Baravata et al.'s analysis was 49 years) and many specifically target women (the percent of all participants who were female in Bravata et al.'s and Richardson et al.'s meta-analyses were 85% and 73%, respectively) [15,76]. The interventions analyzed in both papers frequently targeted individuals with chronic health conditions, overweight individuals, and/or individuals with low levels of baseline daily physical activity. The majority had between 20-50 participants, though a few had several hundred participants. Importantly, many of the interventions reviewed were conducted as part of broader educational or exercise programs.

In contrast, most wellness-focused interventions presented in the HCI literature are evaluated on younger, healthy populations (though there are notable exceptions, e.g. [62]). Participant populations rarely exceed 20, and as such the focus is often on design evaluation and qualitative methods.

Commercial Products

There are many commercial products that incorporate physical activity into game play (e.g. Wii Fit™, Dance Central™ Kinect™) or allow motivated individuals to monitor their physical activity and set goals (e.g. Phillips DirectLife, bodybugg®, Fitbit). Though these products are popular and engaging, there is limited published research regarding their effectiveness in helping average individuals reach fitness goals.

Goal Management

The design of the intervention presented in this chapter is rooted in findings from psychology and health education literature. Existing literature identifies effective goal management strategies that can be implemented into a straight-forward, automated step count interventions. These strategies and their theoretical underpinnings are described in detail in previous chapters. A summary specifically relevant to the intervention presented here is provided below.

Several meta-analyses conclusively show that setting specific, quantitative goals, as opposed to “do your best” or generic goals, improves individuals’ performance at tasks [13,15,56,68]. Since clear, specific goals are easy to integrate into a software intervention, both versions of Salud! used in this study required participants to set or agree to specific step count goals. Additionally, goal management strategies called Action Plans have also been linked to improved goal realization, specifically with regard to health and wellness behaviors [13]. An individual working with Action Plans is required to set specific, actionable and short-term goals, which she is confident in her ability to realize [13,58,68]. The objective of using Action Plans is to increase individuals’ self-efficacy with respect to the new behaviors they are performing. Self-efficacy, a psychological construct that measures an individual’s confidence in the ability to perform a task or behavior, is an excellent predictor of actual performance [4]. This strategy encourages gradual, sustainable, and manageable changes in behavior, which resemble a staircase when visualized on a graph (see Figure 6.1).

One of the participant populations in this study was provided with an interface based on Action Plans, to investigate whether this more theory-driven and sophisticated type of interaction would improve performance. In addition, all participants completed Sherer’s self-efficacy scale instrument [81], a validated measure of General Self-Efficacy (GSE), prior to starting the program.

Description of the Intervention

In order to quantitatively evaluate Salud!’s goal management interface, I created a pedometer-based walking intervention. The secondary goal of this intervention was to investigate whether and how a simple, automated goal management interaction could improve individuals' likelihood of realizing behavior change goals. The objective of the intervention's design was to create a straightforward, automated, and pedometer-based fitness program. To ensure that my research collaborator and I could recruit and support a large study population, the procedure had to be simple and the intervention had to require minimal intervention from the researchers, once participants were enrolled.

I established the procedure for a six-week pedometer-based fitness intervention. The outcome of the intervention was to be for participants to increase their average daily step count by 20% over their baseline. All participants were provided with a pedometer, and an account on the Salud! system where they could track and review their step counts, as well as manage their step count goal. Participants spent the first week of the intervention ("baseline phase") collecting baseline daily step count data. The final five weeks ("post-baseline phase") were dedicated to achieving the step count goal (see Figure 6.3).

This intervention also allowed my research collaborator and me to test two different goal management interfaces embedded into the Salud! application. I randomly split the participants into control and experimental populations. The control population received only the aforementioned 20% overall increase goal. The experimental population also received this long-term goal, but additionally had to set and manage weekly short-term goals. The intervention protocol and the application participants used are described in depth below.

Salud! Interaction Description

The step count intervention was primarily driven by the features of Salud!, which allowed participants to enter and review their step count data (as well as other health/wellness data, if desired). Salud! also handled goal management for users, which will be described below. Lastly, a number of services functioned together with the application to send data entry reminders as well as allow users to enter data via SMS or a mobile application. The full functionality of Salud! is described in detail in previous chapters, and also in [67]; in this chapter I only describe how Salud! was configured for the current intervention.

Every intervention participant was provided with a pedometer, a pre-configured Salud! account, and both written and verbal instructions. Using Salud!, participants could enter their daily step count and view a history of their entries. Users' previous entries were listed in a table and shown on an interactive graph (see Figure 6.1). Users were also given the option of similarly tracking their weight, hours of sleep and exercise using the same interface. This was strictly optional and did not affect any part of the study.

Upon signup, users were given the option of receiving daily reminders to enter their step count data via SMS, email, both, or neither. During the course of the study users also had the option of changing their preference or adjusting the time of message delivery (10:30 PM by default). In addition, users could also enter their step count data via SMS or using a mobile app. The SMS interface only provided the option to enter data, while the mobile app also allowed users to review a list of previous entries.

Goal Management Interactions

The version of Salud! deployed as part of this study had two separate goal management UI modules. The first module, provided to the control participants, overlaid the user's long-term step count goal as a horizontal line on the interactive graph. Once a week, it also presented the user with a reminder of her long-term goal; the user could not enter additional data until she confirmed the goal in the dialog.

The second module took an Action Plan-based approach to goal management by focusing on short-term goals and underemphasizing the long-term goal. The step count graph was overlaid with a line showing the progression of the user's short-term goals (see Figure 6.1); the long-term goal was not shown on the graph. Each week, the user was prompted to manage her short-term goal using the series of steps shown in Figure 6.2. First, the user was reminded of her long-term goal. Then the user was asked to enter a short-term goal, with the option to accept a pre-populated default. Finally, the user was asked to rate her confidence of achieving the short-term goal over the course of the following week, on a scale of 1 to 10. If the user rated her confidence less than 7, she was asked to adjust her short-term goal to a more reasonable target.

Methods

Data Collection and Research Instruments

During the course of the intervention program, I collected qualitative and quantitative data from participants in the form of pre-intervention and post-intervention surveys, logs of user data and activity, and open-ended user feedback. To participate in the program, participants filled out a survey that requested demographic data (age, gender, education level). The survey also asked participants to self-report their level of physical activity over the past six months: Inactive (“never or rarely include physical activity in your day”), Somewhat Active (“light or moderate activity about 2-3 times a week”), Active (“at least 30 minutes of moderate activity most days of the week, or 20 minutes of vigorous activity at least 3 times a week”) or Very Active (“large amounts of moderate or vigorous activity in your day”).

Participants also completed Sherer’s General Self-Efficacy survey instrument [81]. The self-efficacy score is calculated by summing the point values of each of 12 questions, with each answer carrying 1 to 5 points (the range of the scale is thus 12 to 60). There is no accepted cut-off for “low” or “high” self-efficacy. Instead, Schwarzer recommends dichotomizing a given population into low- and high-GSE subpopulations around the median [79].

After the termination of the study, participants were asked to fill out a survey that collected data about self-reported reasons for participating in the study, feedback on the difficulty of the step count goals and open-ended feedback about the program and the online application.

While the study was ongoing, in addition to data directly entered into the online application by participants, the Salud! infrastructure retained data about user’s login patterns, methods of data input (online application, mobile application or SMS) and basic use logs of the goal management module.

Participants

To come up with a desired population size, I decided on a minimum detectable difference in means between the control and experimental group to be at least 500 steps. Based on existing literature, I estimated a standard deviation of 1000. With a study power of .90 and a .05 significance level, this implied a population size of about 170. Because of concerns about the number of participants that my research collaborator and I could effectively handle (especially in case of unforeseen problems), we decided to cap the population size at 150.

I recruited participants for this study in three ways: an advertisement for the study was posted in the university-wide email newsletter, the study was added to the psychology class study recruitment pool and an information table was set up at the entrance to the campus fitness facility. We recruited a total of 143 participants.

The participants were randomly split into the control condition (N=71) and the experimental condition (N=72). All participants filled out the introductory survey. Due to an oversight, the survey data for two participants was not saved; these participants were excluded from all analysis involving introductory survey data.

Of 141 participants who completed the introductory survey, 61 (43%) were female and 80 (56%) were male. Ages ranged from 18 to 66 (mean: 28, median: 23). Participants' general self-efficacy scores ranged from 31 to 59, with a mean of 48 and a median of 48. Table 1 shows the distribution of self-reported activity levels. Slightly more than half of the participants reported themselves to be "Active."

Procedure

I developed an intervention to increase participants' average daily step count by 20% over the course of the intervention. Each participant gathered a week of baseline data, at which time the system automatically set a walking goal of 20% above their baseline daily average. Participants had 5 weeks to complete the goal (see Figure 6.3).

Participants were assigned to one of two goal management conditions. In the control condition, participants received a weekly email notifying them of their prior week's average daily step count, and reminding them of their ultimate goal (a 20% increase over baseline, expressed as steps per day). Before they could enter any more data into the online system, they had to click through a dialog verifying that they understood their goal. In the weekly email, participants in the control condition were encouraged to visit a webpage[8] describing the three principles of Action Plans, outlined above.

Participants in the experimental condition had the three principles of Actions Plans encoded into their interaction with the goal management interface. In addition to a long-term 20% step count increase goal, they set and were evaluated on short-term (weekly) goals that increased in 5% increments. After collecting baseline data, participants were reminded of their 20% long-term goal but also had to set a weekly goal. The system suggested a 5% increase as the first goal, but participants could modify the value. After setting a tentative goal, these participants had to rate their confidence of reaching the goal on a scale of 1 to 10 (see Figure 6.2). If a user's self-reported confidence was below 7, she was asked to adjust the goal to something she was more confident in reaching. The long-term and short-term goals were confirmed once the user self-reported a confidence rating of 7 or higher.

Each week, every participant in the experimental condition received an email reminding her of the personalized long-term goal, reporting her average daily step count for the previous week, and recommending a short-term goal for the following week. Before the participant could enter new data into the online application, she had to go through the goal management interaction described above. Short-term goals were recommended in increments of 5%, starting at a 5% increase from baseline for the first week and increasing by 5% any week that the participant realized the previous short-term goal.

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[8] http://GTsalud.org/welcome/goals

Participants were instructed to wear their pedometer as much as possible during waking hours—including while working, exercising, and being home. Participants were asked not to enter data for any day when they believed they had not had the pedometer on their person for at least 80% of the time. To encourage consistent, daily data entry, participants were asked to enter data every day. Additionally, participants were compensated $0.50 for each day during which logged in to the application and created one or more entries (up to $21.00 in compensation for all 42 days). This compensation schedule encouraged once-daily data entry (which provided maximum compensation) while also allowing participants the flexibility to skip several days without entering data.

Each participant was provided with Oregon Scientific PE980-R AnyWear 3D Slim Pedometer. These pedometers can be worn anywhere on the body as well as kept in a pocket or purse/bag. They have a seven-day memory, so that it is not necessary to remember to reset the step count daily or record data every day. During the introductory session, each participant had her pedometer configured correctly and was instructed on its basic functionality. Through the duration of the study, lost or broken pedometers were replaced at no charge. Finally, participants were compensated an extra $10.00 for returning the pedometer and completing a survey at the end of the study.

Quantitative Analysis

After collecting and organizing the data, I ran a series of statistical tests to address the research questions posed at the beginning of this chapter. I used non-parametric statistical tests to evaluate hypotheses because of the shape of data distributions. The questions I examined were:

1. By how much does the intervention increase the participants' step counts?
2. What are the differences between the control and experimental goal management conditions in terms of step count change and utilization of the application.
3. How effective or ineffective is this intervention for different demographic subpopulations?

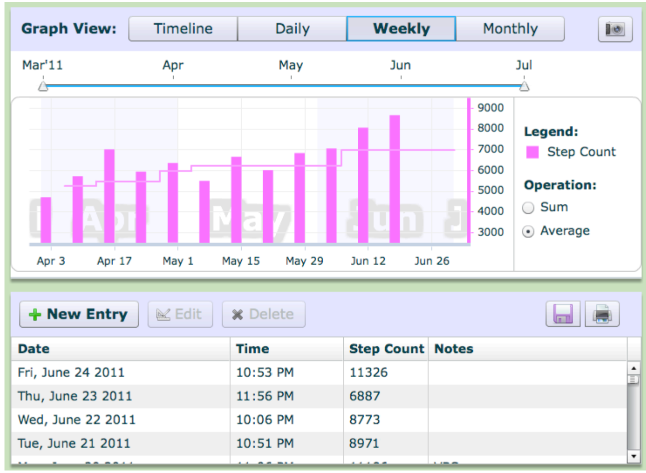

Figure 6.1. Screenshot of a participant's Pedometer Logbook, showing an aggregate weekly view. The thin horizontal line represents the short-term goal (note the up-the-stairs pattern).

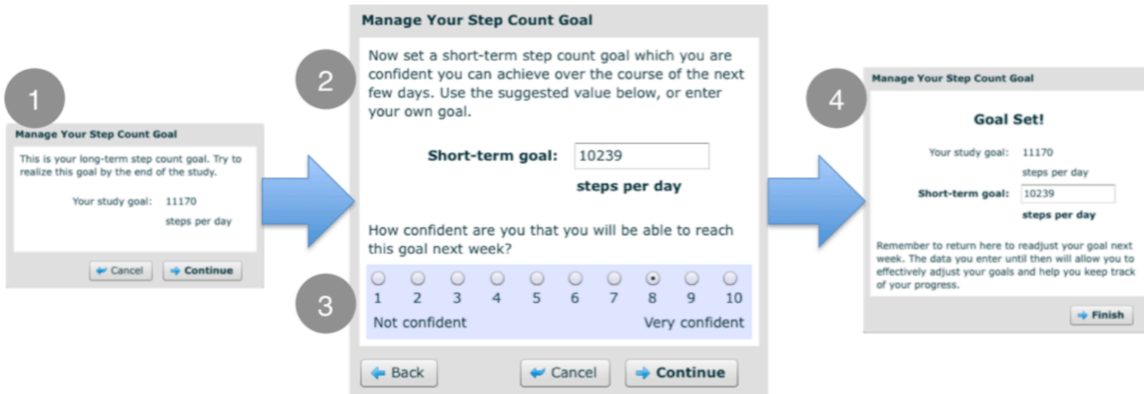

Figure 6.2. Goal management steps for the experimental condition. (1) Reminder of long-term goal, (2) suggested, user-editable short-term goal, (3) confidence validation, (4) confirmation.

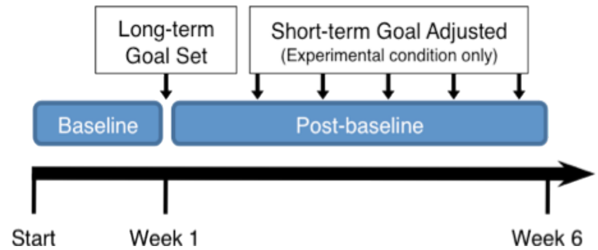

Figure 6.3. Chronological diagram of the intervention, showing the Baseline and Post-baseline phases of data collection.

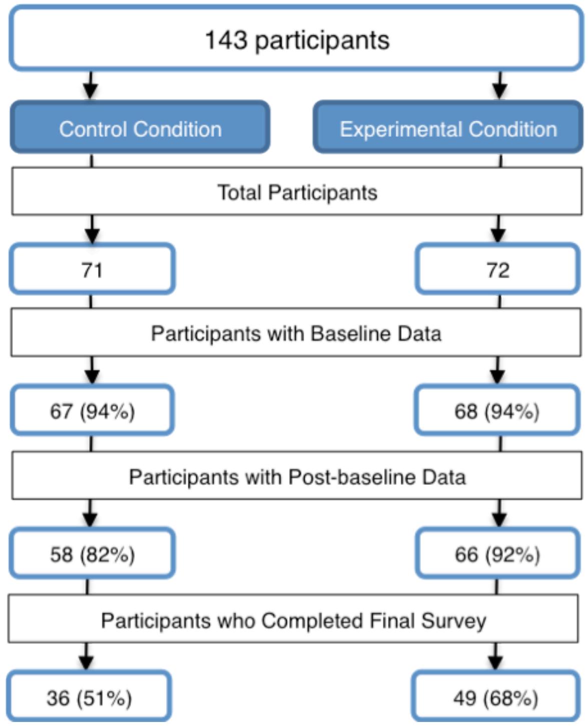

Figure 6.4. Breakdown of participant attrition.

Figure 6.5. Oregon Scientific PE980-R AnyWear 3D Slim Pedometer.

Findings

In this section, I present the statistical findings of the study. First, I discuss the impact of the intervention on the participants' step counts, which showed a significant improvement in both conditions. Next, I focus on the difference between the control and experimental goal-setting conditions to show that a more sophisticated goal-setting interface led participants to utilize the system more frequently. Finally, I illustrate how individual differences in age, self-efficacy, activity level, and baseline step count affected the impact of the intervention on the participants.

Overall Effects of Participation

To examine how the overall intervention impacted participants' step counts, I included all participants who had both baseline and post-baseline data in this portion of the analysis (N=124). On average, these participants logged 9658 steps/day during the baseline period (s.d.=4509, median=8865). The same participants reported walking an average of 10228 steps/day during the post-baseline period (s.d.=4417, median=9112). The average difference between baseline and post-baseline step counts was 652 ($p<.01$, Mann-Whitney U test[9]) with a 95% confidence interval (CI) of 247-1057. A total of 84 participants (68%) increased their average daily step count between the baseline and post-baseline periods. The rest showed a decrease in their average daily step count during this time.

I also considered whether each participant achieved the daily step count goal set for him or her in the beginning of the study (+20% of baseline). Participants achieved their goal an average of 11 days over the course of the 35-day post-baseline portion of the study (s.d.=8.6, median=9).

[9] I used the non-parametric versions of standard statistical tests when the distributions being compared were significantly different from normal (Shapiro-Wilk normality test, $p<.05$).

To summarize, participating in the intervention led to a statistically significant increase in step counts for the participants, and led participants to increase their step count by at least 20% over baseline during an average of 11 days out of 35 possible days.

Effects Across Goal Management Interface Conditions

In the following analysis, I compared the number of steps per day, goal realization, and the frequency of engagement with the system between the control and experimental conditions. Of the 143 participants, 71 were randomly assigned to the control condition and 72 to the experimental condition. Those in the control condition could view only their long-term goal (+20% over baseline), which remained unchanged throughout the study. Those in the experimental condition had shorter incremental goals set for them throughout the study that were automatically adjusted based on the step counts of the previous week and self-reported confidence in achieving the new incremental goal.

Step Count Changes

Table 2 summarizes the difference between the control and experimental conditions, in terms of total steps taken in the post-baseline phase and the average step count difference between the baseline and post-baseline phases. Participants in the control condition took an average of 10,069 steps per day during the post-baseline phase, an increase of 541 steps over their baseline (N=57, s.d.=2509). Participants in the experimental condition took an average of 10,479 steps per day during the post-baseline phase, an increase of 747 steps over their baseline (N=66, s.d.=2055). Neither difference was significant at the .05 level ($p=.63$ for total step count, $p=.39$ for step difference, Mann-Whitney U test). The data shows a trend toward the Action Plan-based goal management interface being more effective, but this trend is statistically inconclusive.

Goal Realization

Participants in the control condition achieved the goal of a 20% increase over the baseline an average of 11 days during the post-baseline phase (N=57, s.d.=9). During the same period, participants in the experimental condition achieved the same metric an average of 12 days (N=66, s.d.=8). This difference was not statistically significant ($p=.68$, Mann-Whitney U test). The lack of statistical significance and small effect size (1 day) suggest that the Action Plan-based goal management interface did not substantially affect this outcome (see Table 6.2).

Engagement and Utilization

I operationalized *utilization* of the system as the number of unique days that a participant logged in to Salud! and entered at least one daily step count. During the course of the study, participants made a total of 4657 data entries. Of these, 1061 entries (23%) were made during the baseline collection week and 3596 (77%) during the five-week post-baseline period. Participants accessed the online application on an average of 20.8 separate days (s.d.=13.5, median=21) out of a possible 42.

Participants in the control condition logged in to Salud! an average of 14 times in the post-baseline phase (N=57, s.d.=12). Participants in the experimental condition logged in to the application an average of 18 times during the same period (N=66, s.d.=12). This difference of 4 days was significant at the .05 level (p=.04, Mann-Whitney U test). In other words, participants who used the goal management interface based on Action Plans were significantly more likely to utilize the system (see Table 6.2).

Additionally, participants in the experimental condition were more likely to engage with the intervention overall. As seen in Figure 6.4, nine participants from the control condition dropped out of the intervention between the baseline and post-baseline phases, compared to two from the experimental condition. A Pearson's Chi-square test showed this effect to be statistically significant at the .05 level, $\chi^2(1, 123)=4.40$, $p=.04$.

Demographic Factors and the Impact of the Intervention

There was a great deal of variance in the step count data of different individuals (as evidenced by the fact that the standard deviation of the difference between participants' baseline and post-baseline step count was more than 2000 steps). To get a better understanding of how specific individual differences affected the intervention results, I dichotomized the population based on age, self-efficacy, activity level, and baseline step count. I additionally broke out the control and experimental condition when looking at the general self-efficacy (GSE) score and the baseline step count. Specifically, I hypothesized that the experimental goal management condition, which is based on GSEelevating Action Plans, would better serve low-GSE individuals as well as individuals who were less active prior to the start of the intervention.

Participant Age and Gender

I split the population into two dichotomized subpopulations around the median age, 23. There were 68 participants aged 18-23 (younger population) and 53 participants 24 years of age or older (older population). The younger population increased their step count an average of 704 steps over their baseline average (s.d.=2337); the older population increased their step count an average of 592 steps over their baseline average (see Table 6.3). This difference was not statistically significant (p=.79, Mann-Whitney U test).

I also compared step count increases across gender. Males (N=67) increased their step count an average of 742 steps (s.d.=2578) while females increased their step count an average of 524 steps between the baseline and post-baseline periods. This effect was not statistically significant (p=.60, Mann-Whitney U test).

In summary, there were no significant differences in how much participants increased their step counts based on age or gender.

General Self-Efficacy (GSE)

I dichotomized the population into a low GSE subpopulation (N=64) and a high GSE subpopulation (N=59) using the median score of 48. Individuals in the low GSE subpopulation who were assigned to the experimental condition performed the best, increasing their step count an average of 1149 steps between baseline and post-baseline. Individuals in the high GSE subpopulation increased their step count by an average of about 350-400 steps, regardless of the condition to which they were assigned (see Table 6.4). Statistical analysis using a generalized linear model showed no significant effects, at the .05 level, of either GSE alone or crossed with experiment condition. Thus, this trend in the data is not statistically conclusive.

Self-reported Activity Level

I examined the difference in step count changes across the activity levels self-reported by participants. As seen in Table 6.5, initially less active individuals seemed to increase their step count more significantly during the course of the intervention. On average, individuals reporting themselves as “Inactive” increased approximately 700 more steps/day, compared to individuals who reported themselves as “Very active”. However, a nonparametric ANOVA analysis did not show the difference in means across groups to be statistically significant at the .05 level.

Baseline Step Count

To further investigate whether users’ baseline activity level has an effect on the intervention’s effectiveness, I dichotomized the population into low and high baseline step groups around the median baseline step count, which was 9108. The number of participants who averaged 9108 or fewer steps per day during the baseline period was 64 (low baseline group); 59 participants averaged more than 9108 steps during the baseline period (high baseline group). The average step increases for individuals in the high and low baseline groups, across the different study conditions, are show in Table 6.6. Statistical analysis using a generalized linear model showed no significant effects, at the .05 level, of either baseline step count alone or crossed with experiment condition. Thus, while the data suggests that individuals in the low baseline group increased their step count by a greater amount than individuals in the high baseline group, this trend is not statistically conclusive.

Utilization of the Online Application

Finally, I compared the number of unique days that individuals from all of the demographic factors described above logged into Salud!. The utilization rate did not differ significantly based on participants’ age, GSE, baseline step count or self-reported activity level; the average for all of these subpopulations was within one day of the global average of 16 days. However, female users logged in during an average of 19 days while male users logged in during an average of 14 days. This difference of 5 days was statistically significant ($p=.02$, Mann-Whitney U test), suggesting that women were much more likely to utilize the intervention regularly.

Table 6.1. Average total step counts and average step count difference across conditions.

Condition	Total Step Count	Step Difference
Control	10069	+541
Experimental	10479	+747

No significant at effects at the .05 level.

Table 6.2. Average number of days that (1) participants used the application and (2) participants met their step count goal.

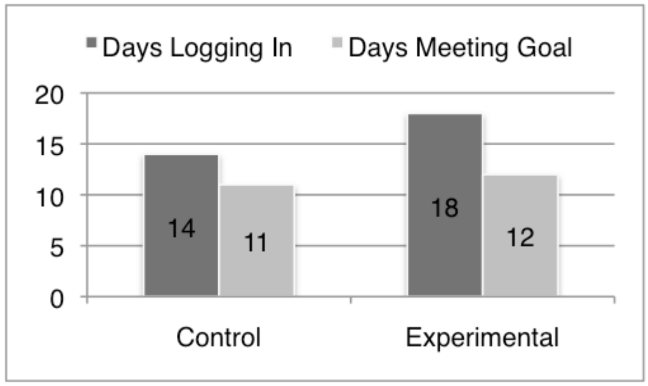

Table 6.3. Average step count increase of the younger and older subpopulations. Effect not significant at the .05 level.

Age	N	Average Step Count Increase
23 years or younger	68	704 (s.d.=2337)
Older than 23 years	53	592 (s.d.=2261)

No significant effects at the .05 level.

Table 6.4. Increase in step count across study and general self-efficacy (GSE) conditions.

	Control	Experimental
Low GSE	666 (s.d.=2275, N=31)	1149 (s.d.=1901, N=33)
High GSE	393 (s.d.=2802, N=26)	345 (s.d.=2152, N=33)

No significant effects at the .05 level.

Table 6.5. Average increase in step count, broken down by self-reported activity level.

Activity Level	N	Average Step Increase
Inactive	10	1039 (s.d.=2203)
Somewhat active	31	937 (s.d.=2106)
Active	58	552 (s.d.=2165)
Very active	22	294 (s.d.= 618)

No significant effects at the .05 level.

Table 6.6. Average increase in step count, shown across high and low baseline step count groups, and the study conditions.

	Control	Experimental
Low Baseline	666 (s.d.=2275, N=31)	1149 (s.d.=1901, N=33)
High Baseline	393 (s.d.=2802, N=26)	345 (s.d.=2152, N=33)

No significant effects at the .05 level.

Discussion of the Findings

Effectiveness of Salud!'s Goal Management Interface

It is interesting that the two types of goal management interactions did not result in significantly different step count increases for their respective user populations (see Table 6.1). I expected participants who used the interaction structured around Action Plans to perform better, as this interaction embodied a goal management strategy that is generally considered to be more effective than simple goal setting [13,58]. Upon reflection, however, I recognize that the abstraction of Action Plans in the present interaction may have been too simplistic. Action Plans are traditionally co-constructed between a patient and healthcare provider, and are evaluated and adjusted based on the patient's personal needs and situation—they are explicitly high-touch. In contrast, the Action Plans used in this study were highly structured and their progression fixed, so that they could be easily encoded into a straight-forward, automated interaction. In future work, it would be useful to examine whether a more sophisticated interaction based around Action Plans may prove more effective. Such an interaction could provide better feedback, allow the user more flexibility in Action Plan structure, and/or provide the means for a healthcare educator to personalize and evaluate users' short-term goals.

However, the Action Plan-based goal management did engage users and led to increased utilization of Salud!. For one, the dropout rate among participants in the experimental condition was lower than among those in the control condition. Additionally, participants in the experimental condition used the online application an average of three days more than control participants. I hypothesize that the increase in utilization and engagement can be attributed to two factors: (1) participants in the experimental condition received weekly requests to manage their goal, as opposed to simply confirm it, as in the control condition; (2) participants in the experimental condition were encouraged to try to realize the 20% goal in steps, rather than all at once.

Low-touch Interventions

A secondary objective of this study was to compare the effectiveness of our simple, low-touch step count intervention to interventions and programs described in the healthcare literature. As previously mentioned, meta-analyses have shown that the use of pedometers and goals increases participants' daily step count by roughly 1500-2500 steps [15,76]. Participants in this intervention increased their daily step count by an average of 652 (95% CI: 247-1057)—a more modest, but still significant, amount. For a rough comparison between these two numbers, consider that an average person with a gait of 2.5 feet (76 cm) walks one mile (1.6 km) in about 2100 steps.

The demographic makeup of the population may have contributed to the smaller-than-expected increase in step counts. Because of the placement of our recruitment station near a fitness facility, my research collaborator and I may have encountered a ceiling effect on step count increase. Sixty nine percent of our participants (N=97) already self-identified as "active" or "very active" and so may have not able or willing to increase their step count as much as a traditional participants of a wellness intervention. Additionally, healthcare interventions are often targeted at high-risk populations or individuals already in the healthcare system due to chronic illness, and these individuals may be more motivated to become healthier than the more general population from which we recruited. Interestingly, female participants were more likely than males to utilize the intervention regularly. This is in concert with Bravata et al.'s and Richardson et al.'s meta-analyses, which show that women tend to be more likely to be targeted by and participate in traditional wellness interventions.

Several statistics suggest that this intervention was more effective for less active individuals, as well as individuals with lower General Self-Efficacy—those who would normally be targeted by wellness intervention programs. Lower GSE participants increased their step count more, on average, than higher GSE participants (see Table 6.4). Also, the increase in step count was markedly higher in individuals who identified as less active than those who identified as more active (see Table 6.5). While these findings are not statistically conclusive, they do suggest that less active and less self-motivated individuals can reap more benefit more than other groups from a low-touch, pedometer-based intervention.

Large-scale Deployments

The HCI community has been recently engaged in a discussion about the evaluation of systems designed to have beneficial societal impact, e.g. improving health outcomes or encouraging environmentally sustainable behavior (e.g. [33,50]). On the one hand, a clear and reasonable argument has been made that many novel and experimental systems should not be evaluated based on RCTs, usability studies, and other traditional evaluation methods [43,50]. These traditional types of evaluations may be premature and shallow in cases where the effectiveness of a system's novel design or experimental new interaction technique is secondary to its other contributions to the state of the art. On the other hand, some researchers have lamented that small-scale evaluations and the lack of controlled studies leave lingering doubts about the utility of the designs proposed by HCI researchers and make it difficult to engage with related academic fields where quantitative evaluations of effectiveness are normative [33,69]. I believe that there is room at HCI for both experimental, innovative designs and for large-scale evaluations of more established technologies—contribution criteria should be applied appropriately to the different types of work. I hope that the study described here can contribute to the growing body of large-scale evaluation work, and serve as a loose model for how such evaluations may be performed by HCI researchers in the future.

The low-touch nature of the intervention used in this study made it possible for it to be administered to a large subject population by a two-person research team. In fact, while the median number of participants in studies described in the medical literature meta-reviews is around 50, we were able to comfortably run three times as many participants. Currently, the effectiveness of this intervention was less pronounced than that of traditional, high-touch interventions. However, a trade-off between the scale made possible by a more generic approach and its overall effectiveness for a specific individual is a trade-off that can be expected of human-centered technical systems. The digitally coded procedure of our intervention allows it to be iterated quickly to test other health-related interactions or strategies. Additionally, the Salud! service stack created as part of this research is presented as a resource for other researchers looking to run data-driven health programs [67].

Study Conclusions

This chapter presented a study of a low-touch, pedometer-based wellness intervention conducted via an online step tracking and goal management application. The results show that a computer-mediated wellness intervention can significantly affect participant behavior, though not as strongly as traditional, high-touch interventions. Additionally, I found that incorporating Action Plans into the system's goal management interactions helps drive utilization of the system; however, the implementation evaluated did not significantly improve behavioral outcomes.

CHAPTER 7

CONCLUSION

Since the start of the work that has gone into this dissertation, the role of personal informatics systems in health and wellness research in HCI has increased. There have been three workshops on personal informatics at CHI [51,53,54] (of which I've helped to organize two), and physical health, mental health, and overall wellness have been a substantial component of each one. Health and wellness now encompass a substantial part of non-academic discourse on personal informatics, in blogs, magazines, and news media (e.g. [41,48,92]). Though the growth of interest in a domain does not tell us about its effectiveness or value, it suggests that others are interested in evaluating the domain's effectiveness as well. I am delighted to be able to substantially participate in, and contribute to, this domain during this time in its evolution.

Interest in the Salud! service stack may also serve as an imprecise barometer of interesting using personal informatics in the various fields of healthcare and wellness. As of the time of writing, various parts of the service stack have been used by four or five small- to medium-sized academic projects. However, there are currently four additional medium- to large-sized projects in various stages of planning whose key personnel are interested in or working towards leveraging Salud! In addition, Salud! is serving as a model for more ambitious personal informatics toolkits, such as Open mHealth.[10]

Summary of Research Contributions

In this dissertation, I presented the design and evaluation of a health-focused personal informatics application called Salud! This system was deployed in two longitudinal settings as a way of exploring personal informatics use in practice, and gathering requirements for a goal management module. The goal management module was designed with reference to a model of goal management which was built to both be

[10] http://openmhealth.org

practically implementable as a software component, as well as to incorporate successful goal management strategies from health self-management (HSM) literature. An additional contribution of this work is the Salud! service stack, which can be leveraged by other researchers to more easily develop personal informatics applications or more quickly run studies where personal informatics functionality is required.

Theoretical Contributions

In Chapter 2, I presented a meta-analysis of HSM research from which I distilled behavior change and goal management strategies that have been shown to be effective in the healthcare and psychology domains. Three of these strategies are related to Action Plans: goals should be short-term and specific; goals should be actionable; and individuals should not set goals that they are not confident they can realize. Additional strategies are the use of cues-to-action to trigger goal-oriented behavior, and the use of small-scale experiments to facilitate the understanding of a goal's context.

I also presented a model of the goal management process, in Chapter 5. This model consists of three components: representation, evaluation, and visualization. The model allowed me to design a goal management interaction that both is implementable as a generalized software module, and preserves the effective goal management strategies from Chapter 2.

Practical Contributions

The Salud! application, without a goal management component, was deployed in two different real-world settings: in a traditional personal training environment, as well as an intensive weight-loss competition (described in Chapter 4). Both deployments ran for several weeks. These deployments allowed me to evaluate how a personal informatics application is used across different fitness contexts. Additionally, the real-world use afforded to the application by individuals who were already actively managing goals provided insights into the goal management process and enriched the generalized model presented in Chapter 5.

Finally, in Chapter 6, I presented a quantitative evaluation of Salud!'s new goal management module, as compared to a simpler goal management interaction. The study showed a modest, statistically significant benefit to the new module in only a limited subset of settings—specifically overall engagement with the study and application, and also with individuals who fell into the lower half of the population ranked by General Self-Efficacy. In addition, the study allowed for a comparison between a low-touch, semi-automated intervention and traditional interventions in the same wellness subdomain.

Limitations

Two major issues limit the scope of the work presented here. The first is that this dissertation ignores social factors in goal management and realization. The only social interaction considered in depth is the dyadic interaction between a personal trainer and a client. However, an individual's social circles provide substantial input into her goal management process: from attitude towards goals, to the motivation to realize them. This important factor will need to be considered in future work.

The second issue concerns the demographics of the deployment populations. All of the trainers and clients/team members in GIT FIT and GT Biggest Loser were either college graduates (some with advanced degrees) or currently enrolled in a major technical university. It's not clear whether their attitudes toward goals, personal informatics, and Salud! specifically would scale to broader segments of society, including individuals living in disadvantaged or low-income communities, as well as individuals without a college education. Especially important here would be an understanding of whether Salud!'s interface is too complex for a broad range of users. The interface hinges on the comprehension of data templates, visual chart patterns, and other concepts that may be much more familiar to a technical college student or general college graduate than they are to an individual not within these categories.

Future Work

A component of this work is the provision of a methodological and logistical model for large-scale evaluations of goal management tools. In Chapter 6, I described a six-week study with 150 participants, which was administered by me and another researcher. Now that the model exists, I hope it will be much faster to run studies of similar scope in order to further investigate the questions left open in this dissertation.

Personalizing Goal Management Interactions

One of the findings from the GIT FIT and GT Biggest Loser deployments is that there are several distinct attitudes that individuals may have towards self-tracking and goal management. These differences in attitude may map to the Transtheoretical Model of Behavior Change (TMM) [73]. It would be useful to explore if this model can bring additional useful structure to the goal management process. For example, the quantitative evaluation described in Chapter 6 could only be provided to individuals in the pre-action or action stages. Or, the goal management interaction could be modified based on an individual's stage in the TMM process, providing a more customized (and potentially relevant and motivating) interactive experience.

Another way to potentially bring personalization into the goal management interaction would be by crowdsourcing aspects of the facilitation process. Many of the aspects of the generalized goal management model presented in Chapter 5 do not require specialized knowledge to set, but yet they cannot be set algorithmically. Leveraging crowdsourcing techniques may be one way to provide facilitation services to individuals who may otherwise not have the resources to take on assistance from a professional. Evaluating goals may be possible to crowdsource as well, especially using more advanced crowdsourcing patterns where multiple individuals must agree on and verify each other's judgments [9,10].

Accountability through Ambiguity

One final opportunity for future work that I present is a further exploration of how it may be possible to instill a sense of accountability in users. As noted in Chapter 4, based on a trainer's actions (or inactions) in Salud!, some participants were able to ascertain the trainer's level of engagement in the system. Yet for some, a sense that the trainer was reviewing data provided motivation through a sense of being held accountable. There may be interesting (and ethical) methods using which would make a trainer's participation in the system more difficult to infer. This may facilitate the trainer in keeping more clients motivated, given limited time (and thus limited logins and use patterns).

APPENDIX A

FIELD DEPLOYMENT EVALUATION SURVEYS

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G.I.T. FIT Introductory Survey

Name: ______________________________ Gender: __________ Age: ___________

Highest Level of Education: _______________ Currently a student? Yes No

How many months have you been training with your current fitness trainer?

Just started < 1 1-3 4-6 7-12 13+

Which best describes your average level of physical activity over the past 6 months?

- ____ Inactive: Never or rarely include physical activity in your day
- ____ Somewhat active: Light or moderate activity about 2-3 times a week
- ____ Active: At least 30 minutes of moderate activity most days of the week, or 20 minutes of vigorous activity at least three times a week
- ____ Very active: Large amounts of moderate or vigorous activity in your day.

What are your goals for your upcoming fitness training sessions (check all that apply):

- ____ Improve overall level of fitness
- ____ Lose weight
- ____ Build muscle
- ____ Improve muscle tone
- ____ Rehabilitate after an injury
- ____ Learn new workout method or improve workout technique
- ____ Training for an event (e.g. a marathon, triathlon, etc.)
- ____ Others (please specify): ____
- ____ Become stronger
- ____ Improve sports performance
- ____ Manage chronic condition (e.g. diabetes, high blood pressure)

____

____

Please answer the following questions about your life experience in general.

Circle how much you agree or disagree with each statement, on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

If something looks too complicated, I will not even bother to try it.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

I avoid trying to learn new things when they look too difficult.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When trying something new, I soon give up if I am not initially successful.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When I make plans, I am certain I can make them work.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

If I can't do a job the first time, I keep trying until I can.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When I have something unpleasant to do, I stick to it until I finish it.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When I decide to do something, I go right to work on it.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

Failure just makes me try harder.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When I set important goals for myself, I rarely achieve them.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

I do not seem to be capable of dealing with most problems that come up in my life.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

When unexpected problems occur, I don't handle them very well.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

I feel insecure about my ability to do things.

Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

Please answer the following questions about your life experience in general.

For each statement, please circle the response category that best applies.

I can always manage to solve difficult problems if I try hard enough.

Not at all true Hardly true Moderately true Exactly true

If someone opposes me, I can find the means and ways to get what I want.

Not at all true Hardly true Moderately true Exactly true

It is easy for me to stick to my aims and accomplish my goals.

Not at all true Hardly true Moderately true Exactly true

I am confident that I could deal efficiently with unexpected events.

Not at all true Hardly true Moderately true Exactly true

Thanks to my resourcefulness, I know how to handle unforeseen situations.

Not at all true Hardly true Moderately true Exactly true

I can solve most problems if I invest the necessary effort.

Not at all true Hardly true Moderately true Exactly true

I can remain calm when facing difficulties because I can rely on my coping abilities.

Not at all true Hardly true Moderately true Exactly true

When I am confronted with a problem, I can usually find several solutions.

Not at all true Hardly true Moderately true Exactly true

If I am in trouble, I can usually think of a solution.

Not at all true Hardly true Moderately true Exactly true

I can usually handle whatever comes my way.

Not at all true Hardly true Moderately true Exactly true

G.I.T. FIT Concluding Survey

Name: ________________________

Please rate the extent to which you agree with the statements below. If you have any comments about a statement's topic, please write them in the space provided.

The data currently stored in my Salud! account is <u>useful</u>.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

The data currently stored in my Salud! account is <u>interesting</u>.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Using Salud! allowed me to identify or establish <u>useful</u> trends/patterns in my life.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Using Salud! allowed me to identify or establish <u>interesting</u> trends/patterns in my life.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Using Salud! made it easier to evaluate progress toward my fitness goals.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Using Salud! improved the communication between me and my personal trainer.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Using Salud! helped me get more out of my personal training sessions.

Not at all   A little bit   Somewhat   To a great extent

Comments: ____

Below are the goals you listed at the beginning of this study. Please answer the questions associated with each goal. Even if you think you've made little or no progress toward a particular goal, please rate how helpful your personal trainer and using Salud! have been at *facilitating* (i.e. assisting or enabling) progress toward it.

Your goal: ______________________________

Over the duration of this study, how much progress have you made toward this goal?

No progress   A little progress   Some progress   A lot of progress

How helpful has your personal trainer been in facilitating progress toward this goal?

Not helpful   A little helpful   Somewhat helpful   Very helpful

How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful   A little helpful   Somewhat helpful   Very helpful

Comments:

____

____

____

Your goal: ______________________________

Over the duration of this study, how much progress have you made toward this goal?

No progress   A little progress   Some progress   A lot of progress

How helpful has your personal trainer been in facilitating progress toward this goal?

Not helpful   A little helpful   Somewhat helpful   Very helpful

How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful   A little helpful   Somewhat helpful   Very helpful

Comments:

____

____

____

Your goal: ______________________________

Over the duration of this study, how much progress have you made toward this goal?

No progress   A little progress   Some progress   A lot of progress

How helpful has your personal trainer been in facilitating progress toward this goal?

Not helpful   A little helpful   Somewhat helpful   Very helpful

How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful A little helpful Somewhat helpful Very helpful

Comments:

___

___

___

Your goal: ___

Over the duration of this study, how much progress have you made toward this goal?

No progress A little progress Some progress A lot of progress

How helpful has your personal trainer been in facilitating progress toward this goal?

Not helpful A little helpful Somewhat helpful Very helpful

How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful A little helpful Somewhat helpful Very helpful

Comments:

___

___

___

Your goal: ___

Over the duration of this study, how much progress have you made toward this goal?

No progress A little progress Some progress A lot of progress

How helpful has your personal trainer been in facilitating progress toward this goal?

Not helpful A little helpful Somewhat helpful Very helpful

How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful A little helpful Somewhat helpful Very helpful

Comments:

___

___

___

Your goal: ___________________________________

Over the duration of this study, how much progress have you made toward this goal?

No progress | A little progress | Some progress | A lot of progress

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How helpful has using Salud! been in facilitating progress toward this goal?

Not helpful | A little helpful | Somewhat helpful | Very helpful

Comments:

____

____

____

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1	2	3	4	5

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Strongly Disagree	Disagree		Agree	Strongly Agree
1	2	3	4	5

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1	2	3	4	5

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Not at all true | Hardly true | Moderately true | Exactly true

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Not at all true | Hardly true | Moderately true | Exactly true

It is easy for me to stick to my aims and accomplish my goals.

Not at all true | Hardly true | Moderately true | Exactly true

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Not at all true | Hardly true | Moderately true | Exactly true

Thanks to my resourcefulness, I know how to handle unforeseen situations.

Not at all true | Hardly true | Moderately true | Exactly true

I can solve most problems if I invest the necessary effort.

Not at all true | Hardly true | Moderately true | Exactly true

I can remain calm when facing difficulties because I can rely on my coping abilities.

Not at all true | Hardly true | Moderately true | Exactly true

When I am confronted with a problem, I can usually find several solutions.

Not at all true | Hardly true | Moderately true | Exactly true

If I am in trouble, I can usually think of a solution.

Not at all true | Hardly true | Moderately true | Exactly true

I can usually handle whatever comes my way.

Not at all true | Hardly true | Moderately true | Exactly true

APPENDIX B

DESIGN SKETCHES FOR FUTURE WORK

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BOTTOM-UP APPROACH

OPEN ENDED GOAL SETTING: EVALUATING HOW TO ACHIEVE OBJECTIVES w/o guided goal setting.

(Premise is weightloss)

1

My weight ▾ goal is 130 lbs

What should I do?

2

WHAT ARE THE CHANGES YOU CAN MAKE TO YOUR DAY?

I CAN: +

3

I CAN: +

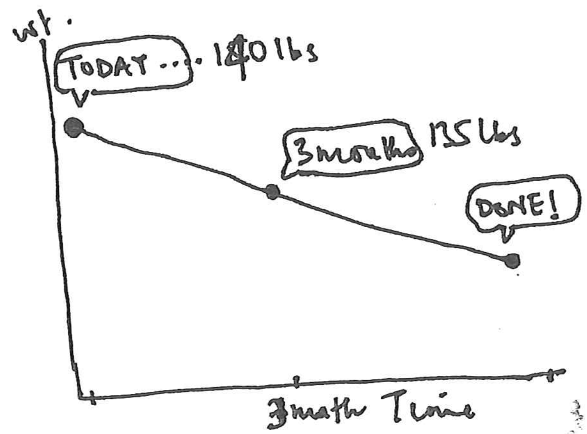
1 Give up a cup of coffee worth 100 calories → LOGBOOK 1

2 Walk an extra mile everyday → LOGBOOK 2

PLEDGE

4

PREDICTION w/ YOUR CURRENT COMMITMENT:



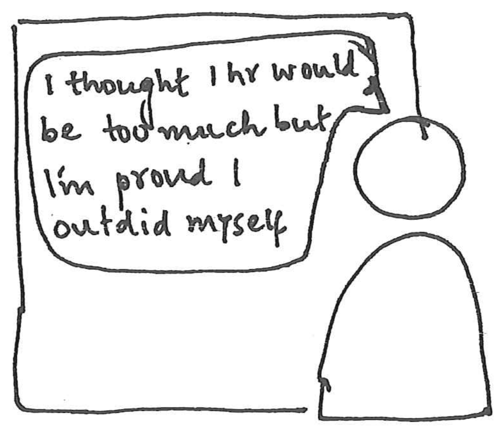
SHORT TERM GOAL SETTING W/ AN AWARE + AVATAR-BASED SYSTEM

2(b)

The system is aware and anthropomorphic

(a) Persuasion: (through vicarious experience)

(b) Accomplishment:



PROCESS: (Pre-goal setting)

Exercise: $\boxed{x}$ min

If x is less:

: I could do more

If x is a lot:

: Umm.. I could try but this seems too much.

If x: optimum:

: This is just right

Post goal-setting

Exercise(log): $\boxed{x}$ min

If x: less;

: I could have done more, I didn't push myself enough

If x: more;

: Wow! I'm pushing limits

If x: optimum:

: I'm on track!

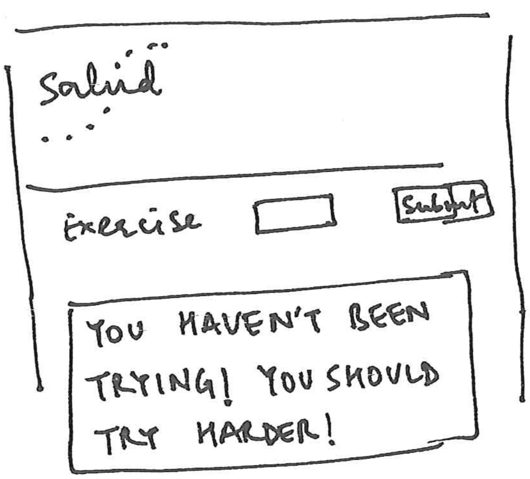
SHORT TERM GOAL SETTING w/ AN AWARE SYSTEM : 2(b)

The system is 'aware' but not anthropo-morphic

Pre-goal setting

Sahid . . .

LET'S TRY A NEW, HARDER GOAL TODAY! (SINCE YOU'VE BEEN MEETING ALL YOUR GOALS)



Post goal setting:

THIS IS GREAT RESULT! EVEN THOUGH YOUR GOAL WAS A 5-mile RUN, 3 miles run is just GREAT TO BEGIN WITH!

SHORT TERM GOAL-SETTING W/ THE SYSTEM: 2(C)

The user preferences as guidelines.

(daily)
Pregoal setting.

EXERCISE : *

SUBMIT

* IMPOSE UPPER & LOWER LIMITS ON EXERCISE

Post-daily goal setting

EXERCISE: 30 minutes

(when goal was: 45 minutes)

The system generates a backlog of 15 minutes for the day

At the end of a week/month etc, it generates a report saying "you are x minutes short of your goal so far" (long term)

SIGN-UP : ADDITIONAL INFORMATION

→

This is to build a personality profile.

1

- How much do you exercise weekly?
- What is your stamina like?

(Questions about the user's perception of himself)

2. (a)

The system becomes 'aware' of the users capabilities etc, and can prompt behavior etc in the future

2(b)

The system generates an avatar of ~~the~~ the 'user' that helps guide the user's decisions by thinking talking aloud

2(c)

The system just uses the ~~guidelines~~ answers from the questionnaire as guidelines

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